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SANSMIC User Manual

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Abstract

SANSMIC is solution mining software that was developed by SNL and is utilized in in Sandia's role as geotechnical advisor to the US DOE SPR for salt cavern development and maintenance. Four SANSMIC leach modes – withdrawal, direct, reverse and leach-fill – can be modeled. This report updates and expands the original 1983 documentation. It provides execution instructions, input data descriptions, input file format, output file descriptions and an example problem.

ACKNOWLEDGMENTS

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Abbreviations and Nomenclature

BBL	–	Barrel (volume unit)
BPD	–	Barrels per day
MB	–	Thousand barrels
MBD	–	Thousand barrels per day
MMB	–	Million barrels
OBI	–	Oil-brine interface (depth)
RW	–	Raw water (unsaturated brine)
SG	–	Specific gravity
SPR	–	Strategic Petroleum Reserve
Bottom-Inject	–	Leach mode where raw water is injected thru lower of two strings. Traditionally called direct leach.
Top-Inject	–	Leach mode where raw water is injected thru higher of two strings. Used primarily for roof development. Traditionally called reverse leach.

Page intentionally left blank.

1 Executive Summary

As part of an ongoing effort of the Sandia National Laboratories (SNL) Strategic Petroleum Reserve (SPR) project to baseline software critical to its mission, this report documents a new user manual for the Sandia developed solution mining code, SANSMIC. This document is one in a series that provides a Quality Assurance (QA) based pedigree for the software.

This report updates and expands the original 1983 documentation. It provides execution instructions, input data descriptions, input file format, output file descriptions and an example problem.

There are four basic types of leaching utilized at the SPR - all four can be modeled by SANSMIC:

- A withdrawal leach requires only one hanging brine string through which raw water is injected into the cavern thereby displacing and lifting the oil out of the cavern through the slick well or annulus for single well caverns.
- A bottom-inject leach, also known as direct-leach, requires two hanging brine strings, where the unsaturated brine injection string is positioned below the brine production string.
- A top-inject leach, also known as reverse-leach, requires two hanging brine strings. Here the strings are opposite that of bottom-inject, in that the production string is deeper than the injection string.
- Oil can be simultaneously injected during either bottom or top injection. This latter process is called leach-fill.

Another common term in use at the SPR is remedial leach which refers to intentional and designed cavern leaching used to expand the available storage volume of a cavern. It is used to counter the volume loss due to creep closure, provide working volume for small cavern-to-cavern transfers that are required during cavern workovers, and to increase the storage capacity of the SPR.

Execution of SANSMIC is through a simple command prompt, menu-driven, user interface coupled with a single, user-generated input file. The menu is used to specify the name of the input file, run SANSMIC, or exit the code. The bulk of this document describes the user inputs and format. SANSMIC generates six output files that sort output data by usage and are distinguished by unique filename extensions, as follows:

A runtime log for input and error processing (*.log*)

A one line per day history containing primary results and important variables (*.tst*)

Snapshots of results and many intermediate variables over the entire computational grid at specified times (*.out*)

A tabular file containing cavern profiles at specified times (*.rad*)

A tabular file containing change-in-radius profiles at the same specified times (.*dra*)

A tabular file containing the initial cavern profile and change-in-radius profiles at the end of each leach stage. This file was originally intended for transferring drawdown leach data to the P2D, (pillar-to-diameter) cavern stability software (.*ddl*)

Each output file is described in detail in the report.

2 Introduction

As part of an ongoing effort of the Sandia National Laboratories (SNL) Strategic Petroleum Reserve (SPR) project to baseline software critical to its mission, this report documents a new user manual for the Sandia developed solution mining code, SANSMIC. This document is one in a series that provides a Quality Assurance (QA) based pedigree for the software. The document set currently consists of the original theory (Russo 1981); original User Manual (Russo 1983); original verification documentation (Reda and Russo 1983; Eyermann 1984; Reda and Russo 1984); a new design document (Weber and Rudeen 2015) and recently released leach reports (Lord, Roberts et al. 2012; Rudeen, Weber et al. 2013; Weber, Gutierrez et al. 2013).

This report updates and expands the original 1983 documentation. It provides execution instructions, input data descriptions, input file format and output file descriptions.

2.1 Background

The United States Strategic Petroleum Reserve (SPR) consists of an underground storage system which uses caverns leached (solution mined) in four salt domes (Big Hill, Bryan Mound, Bayou Choctaw and West Hackberry) located near the Gulf of Mexico in Texas and Louisiana. The SPR comprises 60 active caverns containing approximately 700 million barrels (MMB) of crude oil.

Sandia National Laboratories is the geotechnical advisor to the US Strategic Petroleum Reserve.

2.1.1 Types of Leaching

There are four basic types of leaching utilized at the SPR: withdrawal, top-inject, bottom-inject and leach-fill. A withdrawal leach (Figure 2-1c) requires only one brine string, presumably deeper than the oil-brine interface (OBI), through which raw water is injected thereby displacing and lifting the oil out of the cavern through the slick well. The OBI is moved upward within the cavern and leaching occurs below this depth. The typical leach pattern for a withdrawal leach is such that the majority of the leaching occurs at the injection depth tapering to near zero at the final OBI depth. This pattern can be interrupted or changed due to strategic string cuts or inadvertent string breaks.

A bottom-inject leach (Figure 2-1a), also known as direct-leach, requires two hanging brine strings both of which are positioned below the OBI. The injection string is positioned below the production string which results in the majority of the leaching occurring near the injection string depth tapering up to the production string with less leaching occurring between the production string and the OBI. The extent of the tapering is dependent upon the distance between the injection and production depths, as well as the relative location of the OBI. The OBI may be stationary or moving within the cavern due to concurrent oil injection. Bottom-inject leaching was used for sump and chimney development in the earliest stages of cavern development at the SPR.

A top-inject leach (Figure 2-1b) requires two hanging brine strings, both below the OBI, and was previously known as reverse-leach. Here the strings are opposite that of bottom-inject, in that the brine production string is deeper than the brine injection string. The primary leaching occurs near the injection depth up to the OBI, with leaching tapering down between the injection and production depths. The amount of leaching in a given region is dependent upon the distance between the injection depth and OBI as well as the relative location of the production string. Three top-inject configurations were used for cavern development by the SPR: the first-reverse used a high injection point for roof development; the second-reverse, with the injection at mid-depth, was used for mid to upper cavern development; and third-reverse with injection near the bottom of the cavern for bottom to middle volume development.

Bottom-inject and top-inject is the terminology currently used by the SPR in place of the more traditional direct and reverse leach terminology used by industry because they are more descriptive. Both sets are used interchangeably in the remainder of this report with the historical terminology used when referencing and comparing with historical data.

Oil can be simultaneously injected during either bottom or top injection. This latter process is called leach-fill and was used extensively during the SPR cavern development.

Another common term in use at the SPR is remedial leach which refers to intentional and designed cavern leaching used to expand the available storage volume of a cavern. It is used to counter volume loss due to creep closure, provide working volume for small cavern-to-cavern transfers that are required during cavern workovers, and to increase the storage capacity of the SPR.

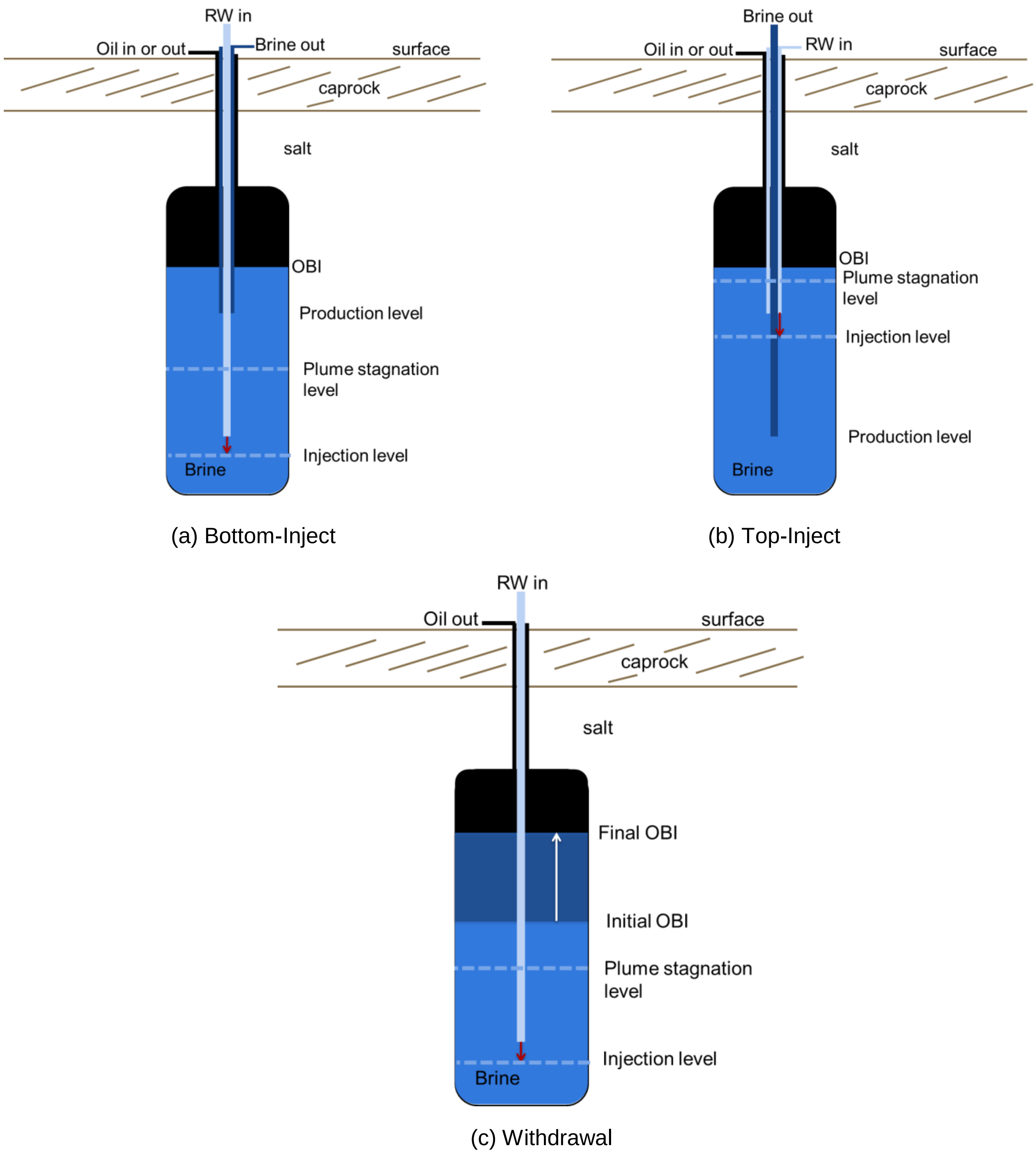


Figure 2-1. Schematics of Basic Leach Scenarios.
In the current version of SANSMIC the plume model is replaced with a mixing-cell between the injection level and plume stagnation level.

2.1.2 SANSMIC History

SANSMIC was developed at Sandia in the early 1980's by A. J. Russo in order to accommodate the pressing directive to create additional petroleum storage caverns quickly. Previously, the

SMRI code SALT77 was used, but the speed at which the caverns were to be filled resulted in a leach-fill scenario with a transient OBI, a capability not available in SALT77. The moving OBI was also required in the modeling of withdrawal leach. Several documents including a theoretical report (Russo 1981) and User's Manual (Russo 1983) and two experimental studies present verification and validation of SANSMIC (Reda and Russo 1983; Reda and Russo 1984). Russo (1983) provides comparisons to early cavern development data for both bottom and top leach (sump-chimney and roof development, respectively). The Reda and Russo reports present comparisons of SANSMIC simulations with laboratory-scale experimental results. However, calculations using the current version of the code were not able to reproduce the earlier SANSMIC results (Rudeen, Lord et al. 2011). It is therefore possible that the current version of the code has gone through undocumented revisions, or modeling was performed at the cavern-scale and results were scaled-down to the laboratory-scale. A repeat of some of the validation work presented in the SANSMIC User's Manual (Russo 1983) is documented in the Validation document (Weber and Rudeen 2014). The updated User's Manual provided by this report completes the series of QA documents for the SANSMIC software.

2.1.3 SANSMIC Application in the SPR

SANSMIC has a broad range of utility at SPR including: remedial leach planning, available drawdown estimation using pillar-to-diameter ratio, and cavern selection for crude oil delivery. It was recently used in an investigation into the feasibility of leaching BM5 and WH9 to more stable configurations. It was also used in selecting and planning remedial leaching activities for the purpose of expanding the reserve's storage capacity and ullage. SANSMIC was used to identify available leaching zones and to estimate storage volumes that could be created which have minimal effect on cavern stability and available drawdowns.

SPR caverns were designed for five drawdown cycles, presumably over a 20 year period. Over the reserve's lifetime, no full drawdown order has ever been given. Thus, only partial withdrawals, like that of the 2011 30 MMB sale, and other comparably sized raw-water movements have occurred. The analysis of these movements has shed light on the potentially deleterious effect of small-volume raw-water movements near the bottom of caverns, which reduced pillar-to-diameter ratios and resulted in the loss of future drawdowns. Recently, SANSMIC was used to predict the future cavern geometry assuming multiple full-cavern drawdowns in order to calculate the projected P/D ratios and resulting number-of-available drawdowns until limiting P/D criteria are violated.

BM5 and WH9 are phase I caverns that were acquired by the SPR and are oddly shaped. It is thought that with prescribed leaching the accessible reserve volume would increase and geomechanical stability might be improved. The investigation is still in the earliest stages and the research and cost/benefit analyses are not complete at this time. If feasibility is shown, SANSMIC would be used in developing leaching plans. It is of note that SPR phase I caverns generally fall outside of the normal geometry for which SANSMIC was written. Such geometry is untested and results are not verified. The implication is that any leach plan for developing odd-shaped phase I caverns must be monitored closely.

3 User Interface

The SANSMIC user interface is minimal as the software is primarily input file driven (circa 1983). A brief discussion of the user interface is provided in this section which is followed by sections detailing the format and settings of the input file and descriptions of the contents of the multiple output files. Upon starting the executable, a command prompt window opens on the screen, as pictured in Figure 3-1, requiring the user to type the root name of the input file which is created manually by the user using a text editor and saved with a .dat extension. The .dat extension is mandatory, but the extension is not to be included in the name given to SANSMIC. The input file must reside in the same directory as the executable. Input file specification is case insensitive. However, output files will use the input filename as root with the exact case as specified by the user. For example, if the input file in the current working directory (cwd) is "mySANSMIC.dat" and the user specifies the file as "MySansmic", the file mySANSMIC.dat will be used but the output files will be MySansmic.rad, MySansmic.dra, etc. It is recommended, that users not have multiple input files that differ only by letter case.

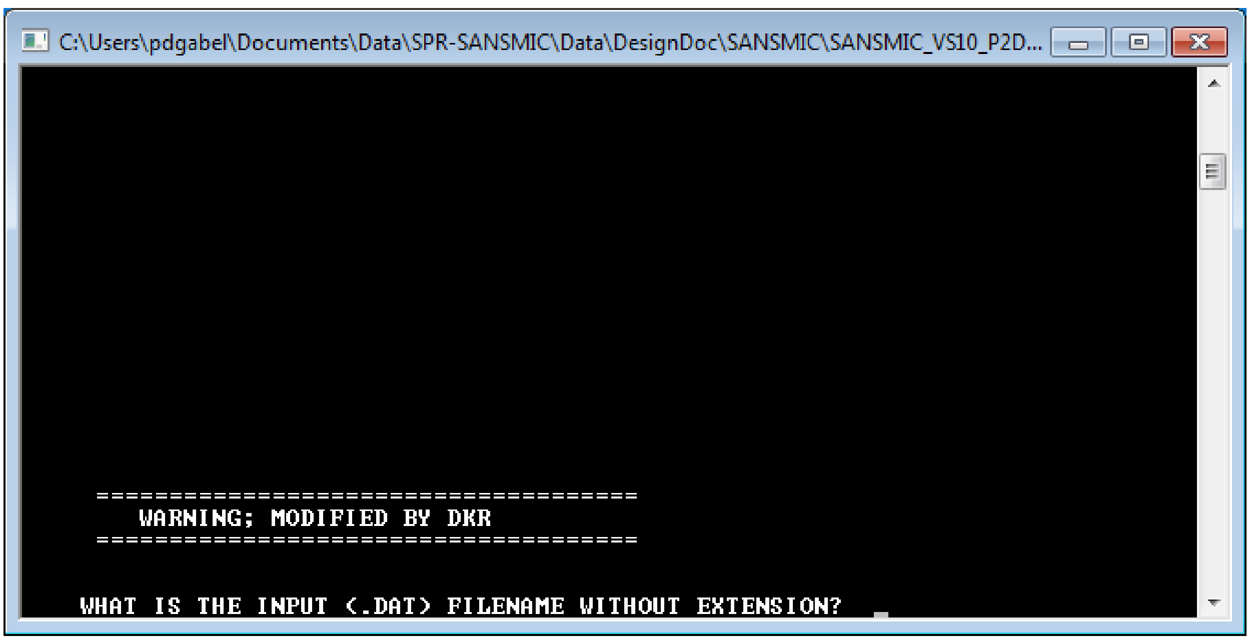


Figure 3-1. Executable Start-Up Screen with Request for the Input File.

If the specified input file cannot be found due to incorrect directory specification or misspelling, SANSMIC displays: "File not found. Hit Enter". The user can then hit Enter and input the corrected file name. It should be noted the filename is limited to 16 characters excluding the extension. If the file name is longer than 16 characters, the same "File not Found" error will be shown.

Once the input file is selected, the Main Menu of SANSMIC is displayed as shown in Figure 3-2. There are currently only three working options available and in each case the user simply types the integer of the option and then presses “Enter”. The first option is “New File”. Here the user can see the currently specified input file, but if a different input file is desired, the user may choose option 1 and will be returned to the previous screen in which a new input file will be requested (see Figure 3-1). Option 2, “Edit File”, a primitive input file editing option is, no longer supported or available because better capabilities are provided by the Windows environment. Option 3, “Run SANSMIC”, will run SANSMIC on the currently selected input file. Option 4 allows the user to exit SANSMIC completely.

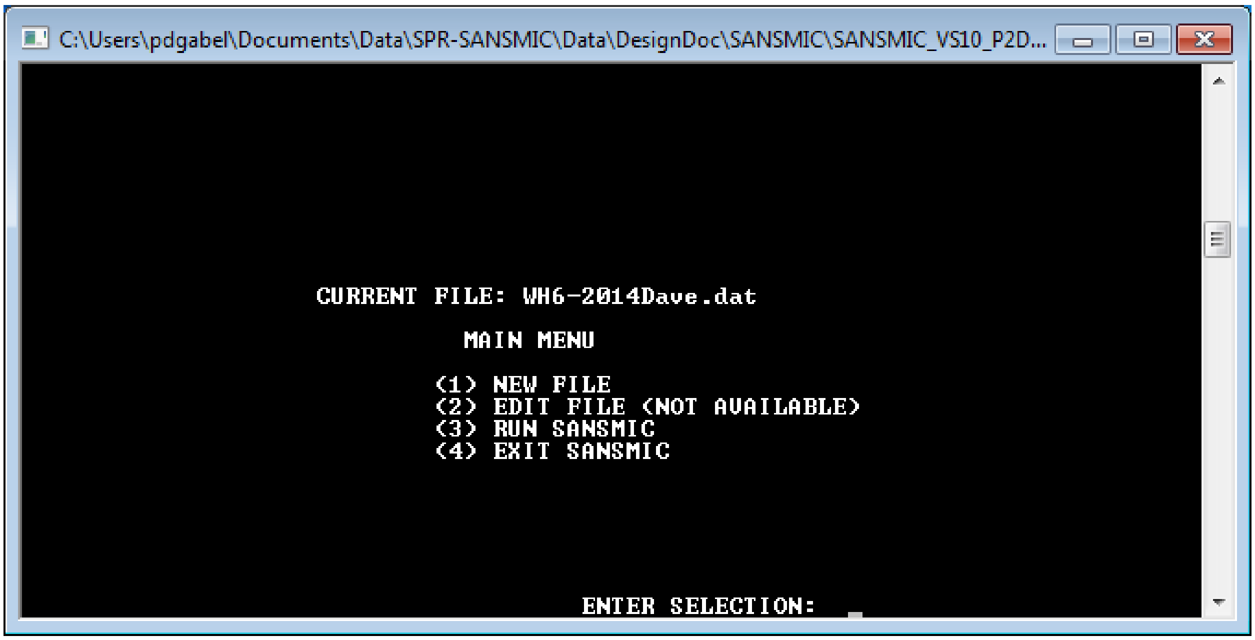


Figure 3-2. SANSMIC Main Menu with User Options.

If the user has selected option 3, “Run SANSMIC”, the screen will resemble Figure 3-3 as the executable runs. The first column denotes the stage of the input file that is currently being run. The second column gives the current simulation time. The third column states the total volume of the cavern and includes both brine and oil volume. When the execution progresses to subsequent stages a message is printed to the screen but is not shown here.

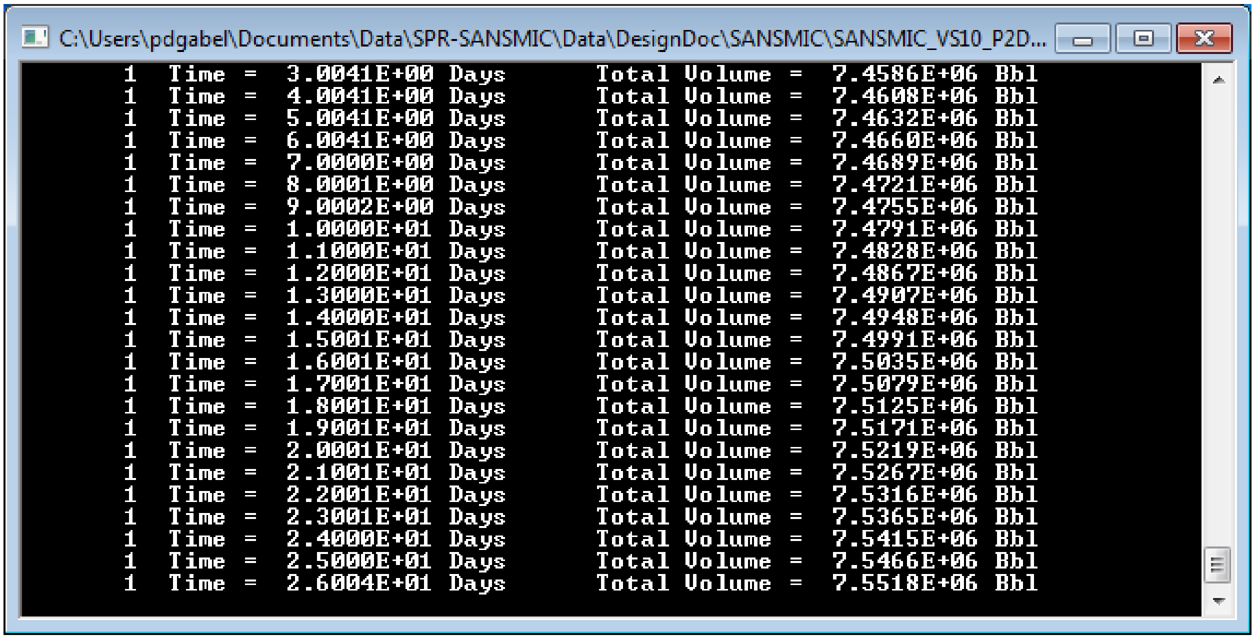


Figure 3-3. Example of SANSMIC Screen as the Program Runs.

Upon completion of the SANSMIC run, the window resembles Figure 3-4. A currently meaningless computation time is given (actual execution times are usually under a minute). When the user presses “Enter” the executable exits and returns to the Main Menu.

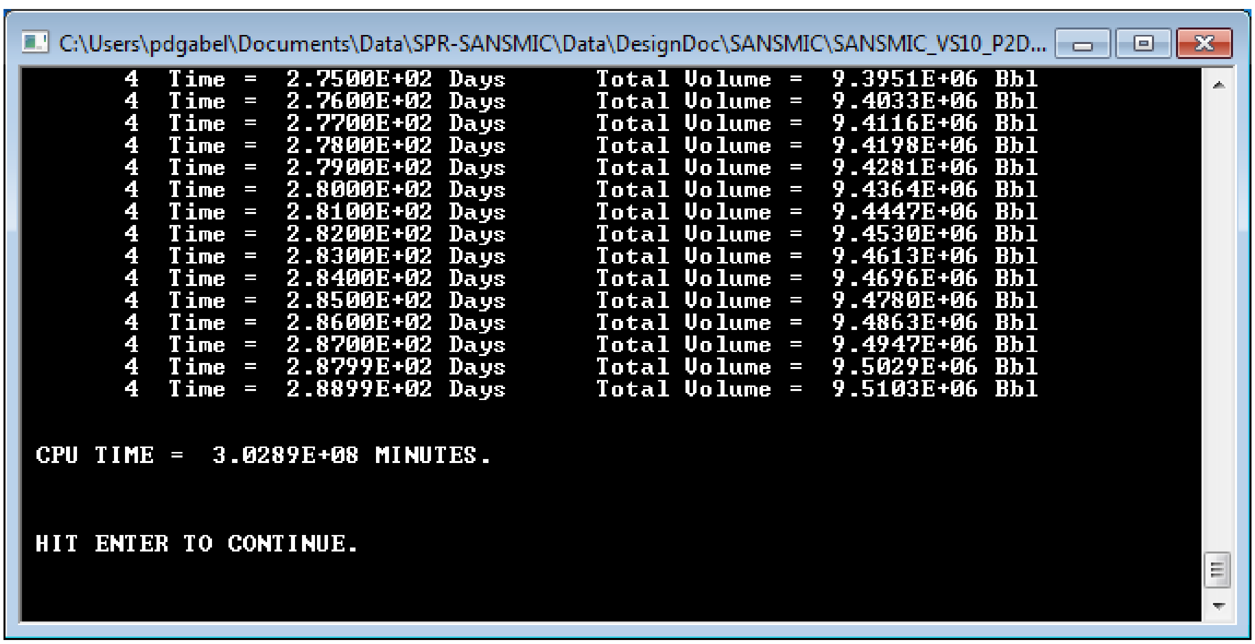


Figure 3-4. Example of SANSMIC Screen at the Completion of the SANSMIC Run.

3.1 Error Processing

SANSMIC echoes the input file, line-for-line to the log file (section 5.1). This is done as SANSMIC reads and processes the file. Unfortunately, SANSMIC does not trap or exit gracefully for some user input errors or problem specification incompatibilities. The best way to debug a SANSMIC input file is to refer to the log file and determine the last input data that was read and processed successfully. The user can then assume that SANSMIC aborted with an error if the screen captured in Figure 3-4 is not displayed showing normal termination.

4 Input File

The input file can be broken into three basic sections. The first section is the stage settings, the second is the cavern geometry and the third section consists of subsequent stages, if necessary, that are similar in format to the first stage. In this section of the report, an example file will be presented, then each input section, and finally each variable will be introduced. A schematic illustrating critical problem parameters is provided in Figure 4-1 and an example input file is presented in Figure 4-2 with annotations for the basic sections. The break down into the stages is separated with the stage title line and first stage settings noted on the left in blue and red, respectively. The cavern geometry follows the settings section in the first stage only (shown to the left with orange). Finally, stages 2 and 3 are shown each of which is preceded by a title line (noted again with blue on the left). The file is ended with one line stating “END”.

Not shown are any number of comment or spacer records that can precede a stage and must begin with “$” in column 1 followed by a space.

Finally, data on an input record is free-formatted and entities can be either blank or tab delimited.

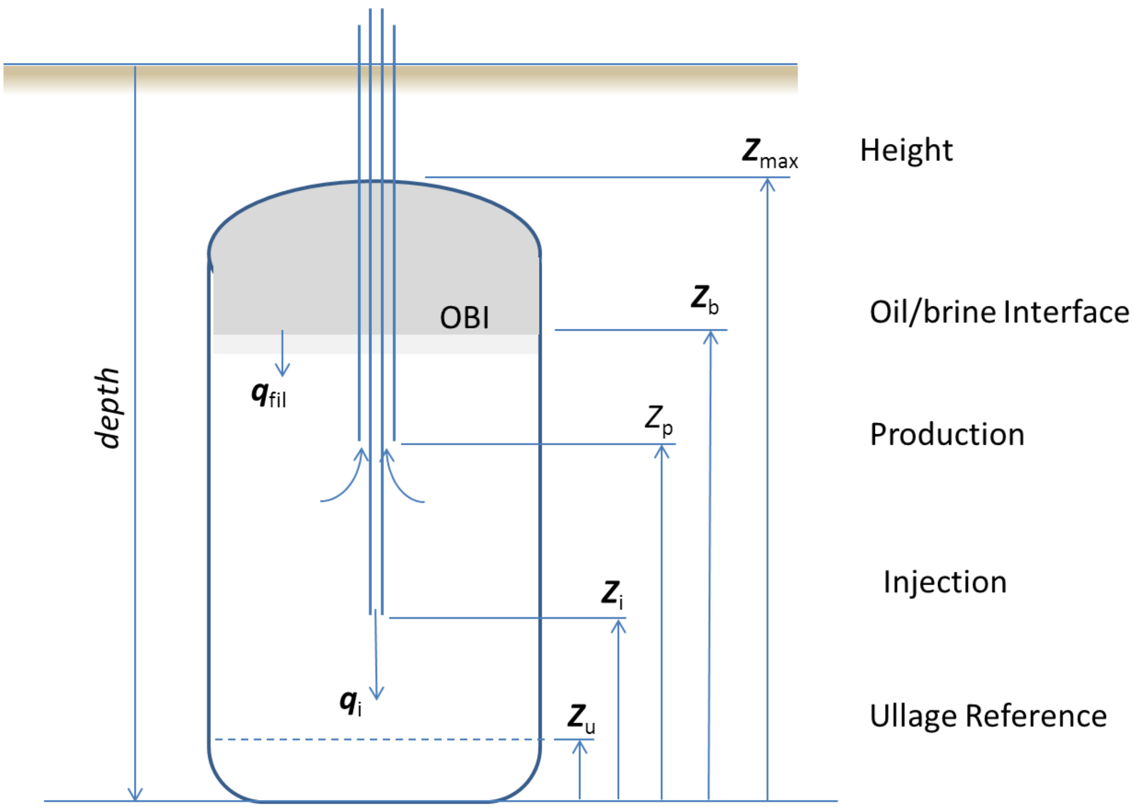
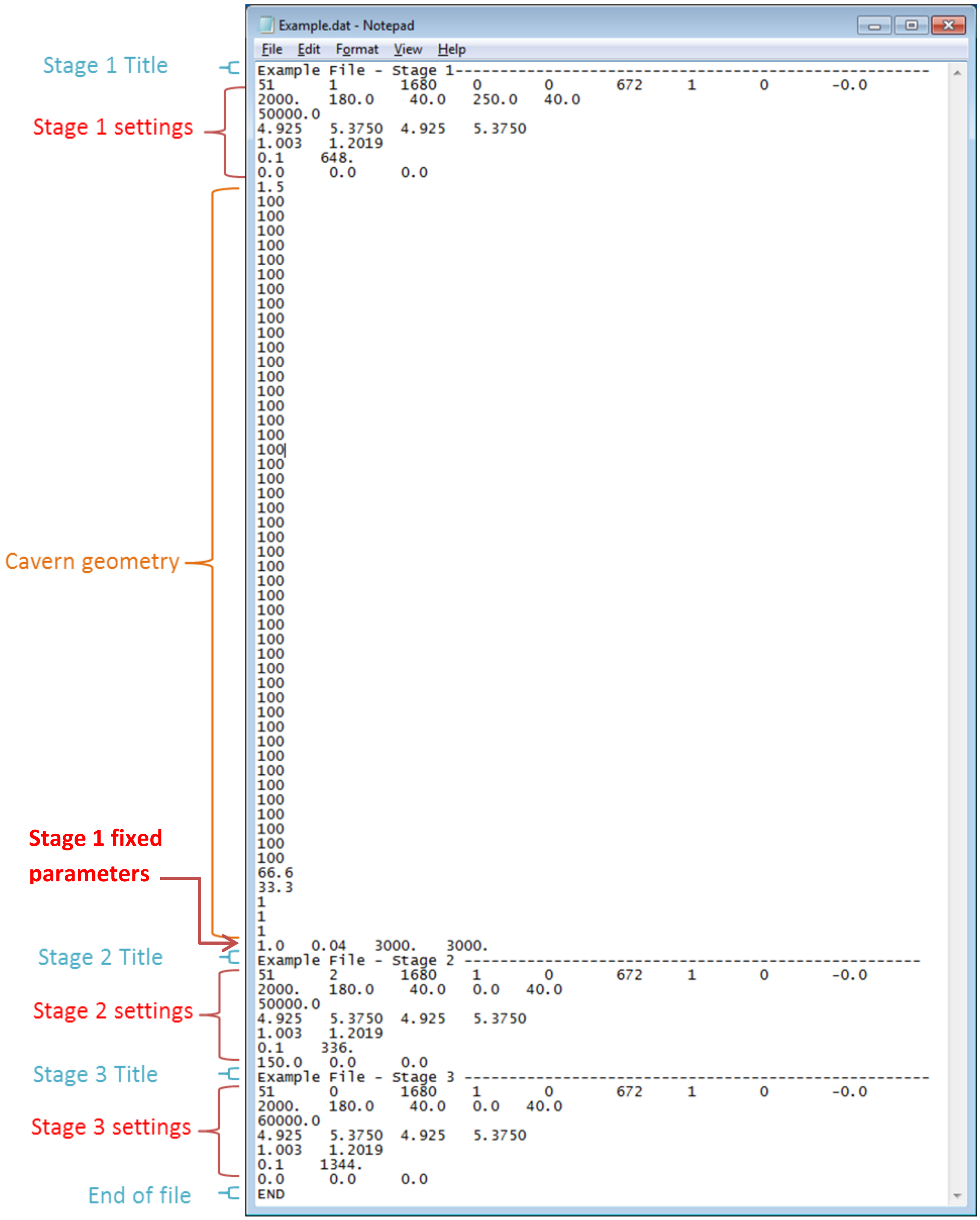


Figure 4-1. Schematic Illustrating Critical Setup Parameters.



```
Example File - Stage 1------------------------------------------------------------
51      1       1680     0       0       672     1       0       -0.0
2000.   180.0    40.0   250.0   40.0
50000.0
4.925   5.3750  4.925   5.3750
1.003   1.2019
0.1    648.
0.0     0.0     0.0
1.5
100
100
100
100
100
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100
100
100
100
100
100
66.6
33.3
1
1
1
1.0   0.04   3000.   3000.
Example File - Stage 2 -----------------------------------------------------------
51      2       1680     1       0       672     1       0       -0.0
2000.   180.0    40.0   0.0    40.0
50000.0
4.925   5.3750  4.925   5.3750
1.003   1.2019
0.1    336.
150.0   0.0     0.0
Example File - Stage 3 ------------------------------------------------------------
51      0       1680     1       0       672     1       0       -0.0
2000.   180.0    40.0   0.0    40.0
60000.0
4.925   5.3750  4.925   5.3750
1.003   1.2019
0.1    1344.
0.0     0.0     0.0
END
```


Figure 4-2. Example of an Input File with Simple Cavern Geometry.

4.1 Stage Title and Settings

When devising a leach plan or modeling a leach scenario, it is important to break the entire leach period up into phases (or stages) for which constant rates and string positions are appropriate. Below, in Figure 4-3, the lines for setting the stage parameters are annotated to the left. The first line is the stage descriptive title. The second gives general information about the type of leach and computational parameters. The third line gives hanging string and reference heights relative to the cavern floor (as opposed to depths). The fourth is the injection rate of raw water or unsaturated brine[1]. The fifth line contains the properties of the injection and production casings. The fifth gives the saturation levels of the injected and resident fluids. The sixth deals with the time step and stage duration and the seventh line contains the oil injection rate and miscellaneous settings.

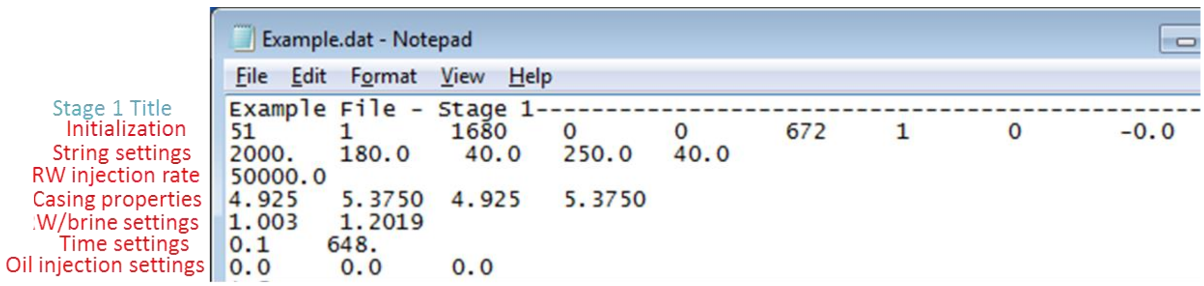


Figure 4-3. Stage Title and Settings Overview.

4.1.1 Stage Title Input Record

The title line is used for clarification and documentation. It is highlighted in the top of Figure 4-4. The title line is reprinted in several of the output files.

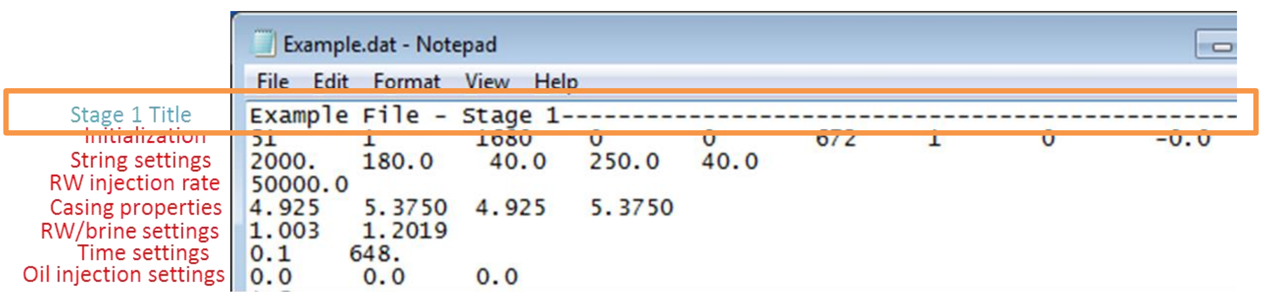


Figure 4-4. Stage Title Input Record Details.

Prior to the title record, but not shown in Figure 4-4 are any number of comment or spacer records that can precede a stage and must begin with "$" in column 1 followed by a space. It is

[1] A time dependent injection capability has been added to SANSMIC that is currently unverified. It was intended for reproducing the complicated fluid movements during development of SPR caverns. The model is described in an appendix for those interested in exploring its use.

good practice to give thorough comments throughout the input file, especially if the input file contains many stages.

4.1.2 Initialization Input Record

The initialization line is highlighted in the top of Figure 4-5 and repeated at the bottom with annotations. The name of each variable (as it appears in the source code) is given in light blue at the top of each annotation box. A brief description or list of options follows in dark blue. Details for each variable are provided below the figure.

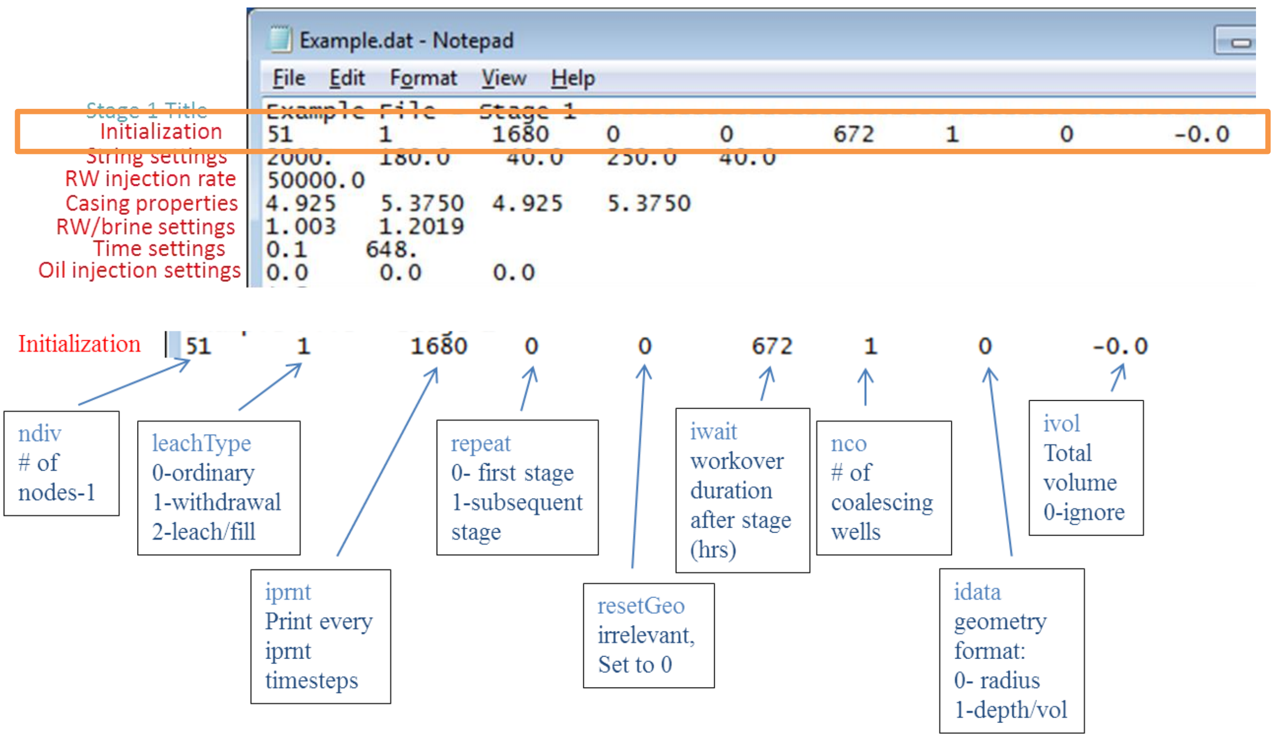


Figure 4-5. Initialization Input Record.

ndiv – The number of divisions or number of cells in the simulation grid. The number of nodes or grid points, for which coordinates are provided later in the input file, is ***ndiv*** + 1. The maximum value for ***ndiv*** is 500.

leachtype – The type of leach operation to be modeled for the stage.

0 – Indicates ordinary leach in which the OBI remains fixed - either bottom-inject or top-inject leach. The code will assume a bottom-inject scenario if the injection string is specified deeper within the cavern than the production string, and a top-inject scenario if the injection string is specified higher within the cavern than the production string.

1 – Indicates a withdrawal leach in which unsaturated brine is injected and the OBI moves up within the cavern as a result of displacement.

2 – Indicates leach/fill operation in which top or bottom inject leaching takes place, depending upon the string depths, and oil is also injected concurrently moving the

OBI down within the cavern.

iprnt – Specifies how often to print statistics to the execute window and output files – there is a print statement every ***iprnt*** time-steps. Therefore, if the time-step is chosen to be every 0.1 hours and ***iprnt*** is chosen to be 1680, then statistics will be printed once per week (1680=24*7*10). Statistics are additionally printed at the beginning and end of every stage and the beginning and end of a workover.

repeat – Designates if this is the first or subsequent stage in the input file. If ***repeat*** is set to 0 it is the first stage, otherwise if it is set to 1 it is a subsequent stage.

resetgeo – The variable ***resetGeo*** is now irrelevant and should always be set to 0. It is a hold-over variable from when computer resources were more limited and a simulation might need to be restarted where a previous run had left off.

iwait – The number of hours of workover time to include at the end of the stage. After a stage of leaching a workover to move strings may be expected during which no unsaturated brine or oil is injected within the cavern, however, during this time leaching within the cavern will continue. It is also important to add a workover to the last stage if the long-term geometry of the cavern is needed.

nco – The number of wells to be coalesced during sump or initial cavern development. It is used during the first phase of a cavern development before the wells have coalesced. For fully developed caverns ***nco*** should be 1. When developing a new cavern with multiple wells (for example 2) during the sump creation stage prior to their coalescing, one would set ***nco*** to 2 and the geometry given in the input file would be the initial geometry for each of the wells. See section 4.1.8 for separation distance, ***sep***.

idata – Specifies the format of the geometry data provided later in the input file as follows:

For ***idata*** = 0

- a list of ***ndiv***+1 cavern radius values are input from the bottom of the cavern up – an example is shown in Figure 4-2. Constant grid spacing is determined by SANSMIC from cavern height (***zma****x*) / number of divisions (***ndiv***).

For ***idata*** not equal to 0, the number of geometry data points, ***ndata***, is specified, followed by:

- for ***idata*** = 1; a list of ***ndata*** depths followed by a list of ***ndata*** cavern volumes.
- for ***idata*** = -1; a list of ***ndata*** depth and cavern volume pairs.
- for ***idata*** = 2; a list of ***ndata*** depth and cavern radius pairs.

For these cases the input geometry data is converted to radius, if necessary, and linearly interpolated to ***ndiv*** +1 uniformly spaced grid points.

Cavern volumes are cumulative from the cavern roof and input from the bottom up. The inputted cavern volumes are converted to radii by SANSMIC. For cases where depth is specified, data can be specified from bottom up or top down. Further detail about the geometry data is given in Section 4.1.9.

ivol – In recent versions of SANSMIC ***ivol*** is only used during withdrawal leaching. For ***ivol*** > 0 the stage is stopped when the volume of oil remaining above the OBI drops below ***ivol*** bbls**.** For ***ivol*** < 0 it is the depth of the OBI, in ft, at which to stop the current stage. Originally, the variable ***ivol*** was used as an option for setting an upper limit on the total volume of the cavern during leaching. The stage would conclude when the duration of the leach is finished or when the cavern has reached the volume set by ***ivol***, whichever occurs first. If the value is 0 this feature is ignored.

4.1.3 String Settings Input Record

Depths of the strings are important to defining the type (top or bottom-inject) and character or focus of the leach. Though strings are typically discussed in terms of depth, SANSMIC actually uses the height above the initial cavern floor instead of depth. In Figure 4-6, the string settings line is highlighted in the top of the figure and repeated at the bottom with annotations. Each variable is presented in detail below the figure. String settings are specified in feet. See Figure 4-1 for a schematic representation of some of these variables.

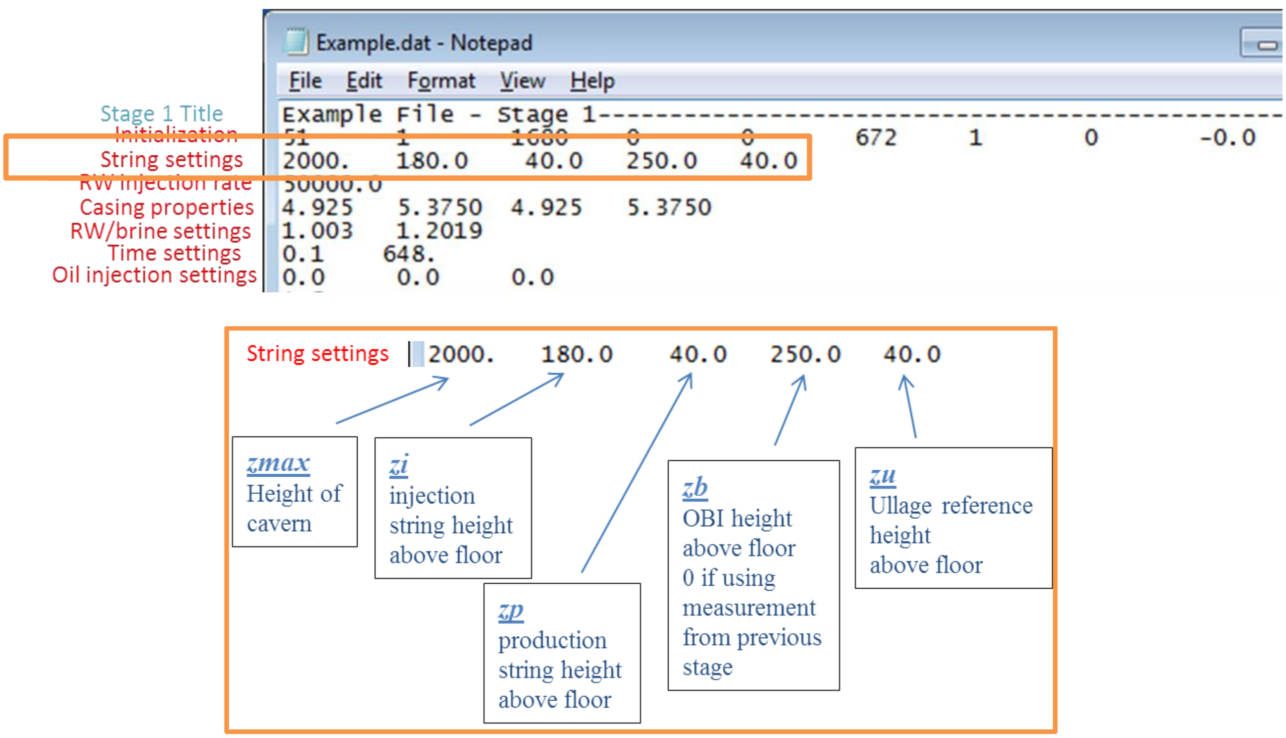


Figure 4-6. String Settings Input Record.

zmax – Height of the cavern in feet. In this case, the height is stated to be 2000 ft and so the top of the cavern geometry data is 2000 ft above the initial cavern floor. This variable defines the size of the computational grid. Node spacing, Δz, is calculated from ***zmax*** / ***ndiv*** supplied on line 2

zi – Height of the end of tubing for the injection string above the cavern floor, in feet. If, for example, the top of cavern was at a depth of 1000 ft, the floor of the cavern was at a depth of 3000 ft, and the injection string was set at a depth of 2820 ft, then the ***zi*** variable would be 180 ft (3000-2820) as shown in Figure 4-6.

zp – Height of the end of tubing for the production string above the cavern floor, in feet. Using the same cavern example as for the variable ***zi*** (depth of cavern floor is 3000 ft) and the end of the production tubing is set at a depth of 2960 ft, then the ***zp*** variable would be 40 ft (3000-2960).

zb – Height of the oil-brine interface (OBI) above the cavern floor, in feet. Continuing the same example, if the OBI is set at a depth of 2750 ft, then the variable ***zb*** is 250 ft (3000-2750). However, if this is the second or a subsequent stage setting ***zb*** = 0 forces the OBI location to be the same as was calculated at the end of the previous stage.

zu – Height of the ullage reference point above the cavern floor, in feet. Ullage or volume available for oil storage is defined as the cavern volume between the reference point and the OBI. Typically, the reference point is 10-20 feet above the operational depth of the hanging string which provides a buffer against emulsion formation due to brine injection. A cavern is considered full of oil when the OBI is at this reference point. The change in cavern volume above ***zu*** is the useable leached volume.

4.1.4 Raw Water Injection Rate Input Record

The raw water injection record has only one variable, ***qi***, the raw water injection rate in bbls/day as shown in Figure 4-7. For the SPR this variable is generally above 50,000 and more often around 100,000 for oil delivery or receipt but can be much smaller for operational maintenance transfers.

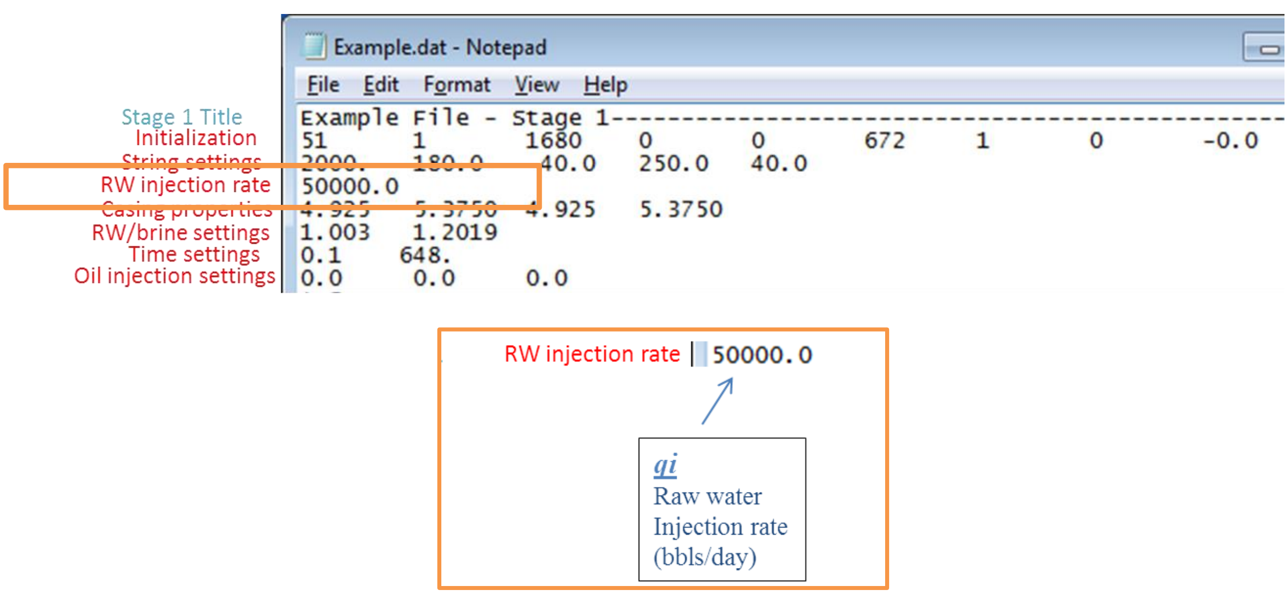


Figure 4-7. Raw Water Injection Setting Input Record.

4.1.5 Casing Properties Input Record

Tubing and casing input data are used to set parameters in the jet and plume models. It should be noted that the SANSMIC model does not assume concentric strings as implied by the data on this record. That is, the annulus cross-section between the inner and outer casing is not relevant. The naming convention is likely a holdover from an earlier version of the code. The stage settings are shown in the top of Figure 4-8 with the casing line highlighted and then the casing record is repeated at the bottom with annotations. A description of each variable is provided below the figure. Casing properties units are inches.

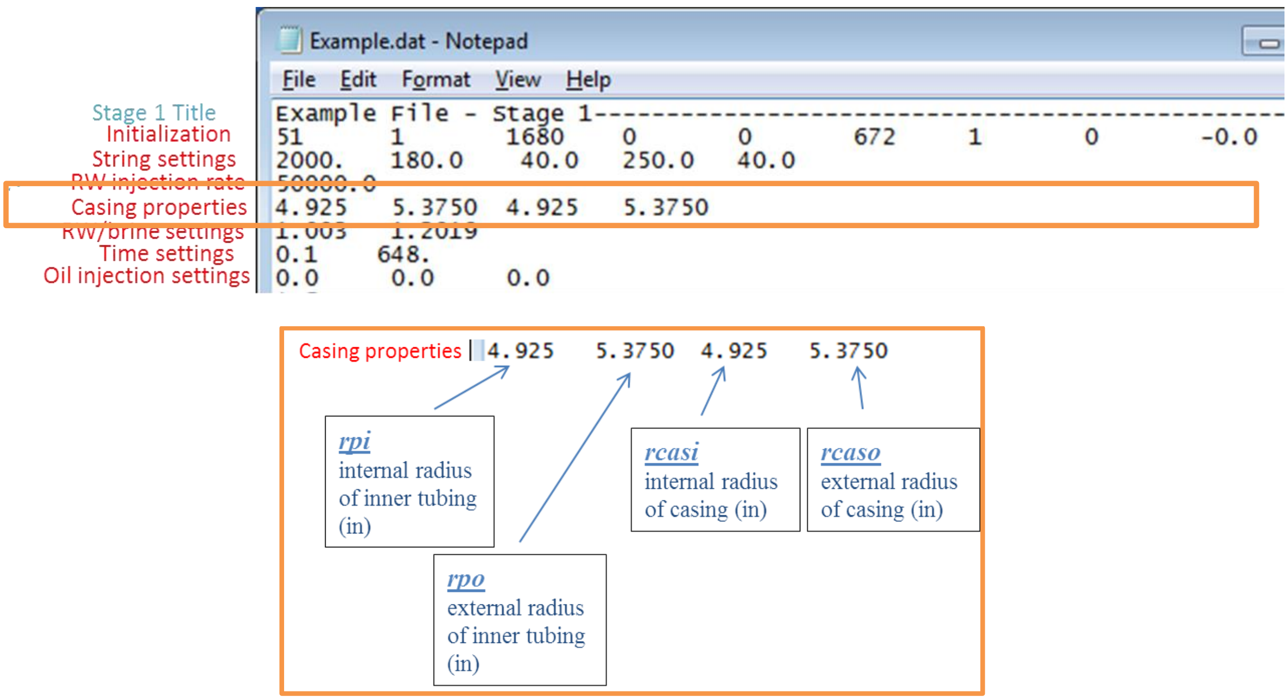


Figure 4-8. Casing Properties Input Record.

rpi – Internal radius of the inner tubing, in inches. It is used within the jet model to calculate the jet length and jet velocity.

rpo – External radius of the inner tubing, in inches; this variable is not utilized within the code.

rcasi – Internal radius of the outer casing, in inches; this variable is not utilized within the code.

rcaso – External radius of the casing, in inches. It is used to determine the initial radius and velocity boundary conditions for the injection plume model.

4.1.6 Raw Water and Brine Settings Input Record

The next input record, which gives the injection brine and cavern brine saturation levels, is highlighted in the top of Figure 4-9 and repeated with annotations in the bottom of the figure. Typical values are approximately 1.03 for sea water, 1.00 for pure water, and ~1.2 for saturated brine. Note that the SANSMIC model currently assumes a constant temperature of ~75 ^{o}F.

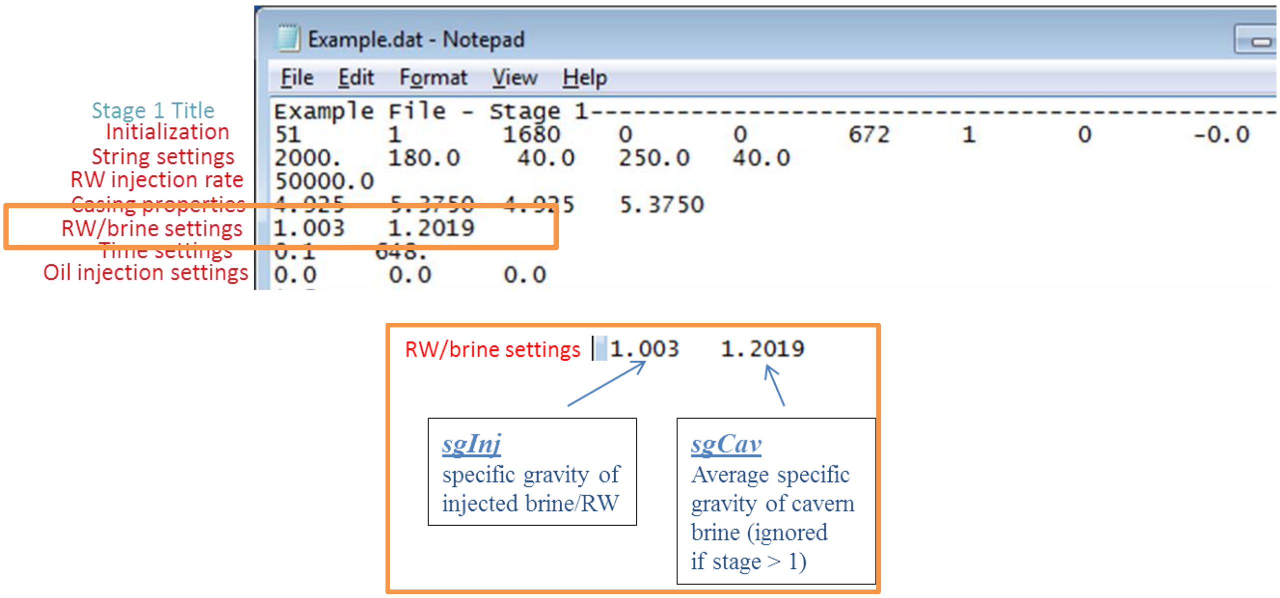


Figure 4-9. Raw Water and Brine Settings Input Record.

sgIn – Specific gravity of injected brine stream. Typically 1.00 or 1.03 for SPR modeling

sgCav – Initial specific gravity of the brine within the cavern. If the cavern has recently had raw water injected and the average specific gravity is known, specify it here. If, however, the cavern has been dormant for a long period the value of saturated brine – 1.2 or 1.2019 as shown here – would be appropriate.

4.1.7 Time Settings Input Record

The next input record, dealing with the time control specification for the simulation, is highlighted in the top of Figure 4-10 and repeated in the bottom of the figure with annotations. Units of time is hours.

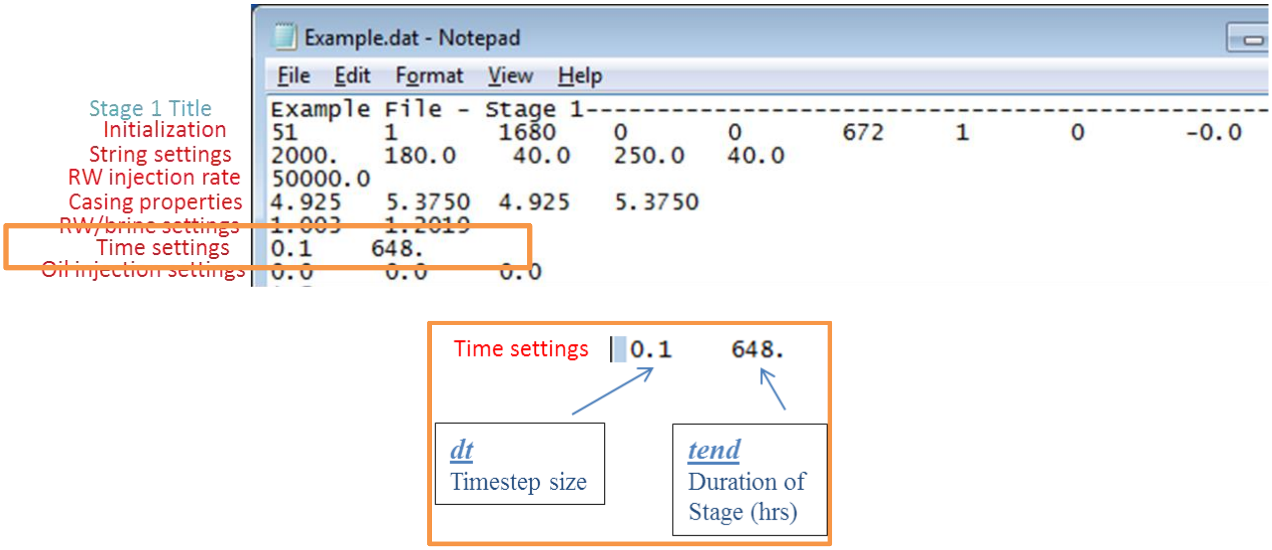


Figure 4-10. Time Settings Input Record.

dt – Size of the time step in hours, so the above figure shows a time step of 0.1 hours. Recall that the statistics are reported every ***iprnt*** time steps. If ***dt*** is too large, important features of the analysis may be missed or the solution algorithm could fail. If the ***CFAC*** (section 5.2 **.out* Output File Description) variable is different than 1 then decrease size of time step. Fraction of days is typical.

tend – Duration of the stage in hours. The value given here is 648 which would imply 27 days of leaching activity prior to the workover duration, if any (***iwait***, section 4.1.2).

4.1.8 Oil Injection Input Record

The final line of the stage settings for stages > 1 contains the oil injection and miscellaneous parameters as shown highlighted in the top of Figure 4-11 and repeated at the bottom with annotations.

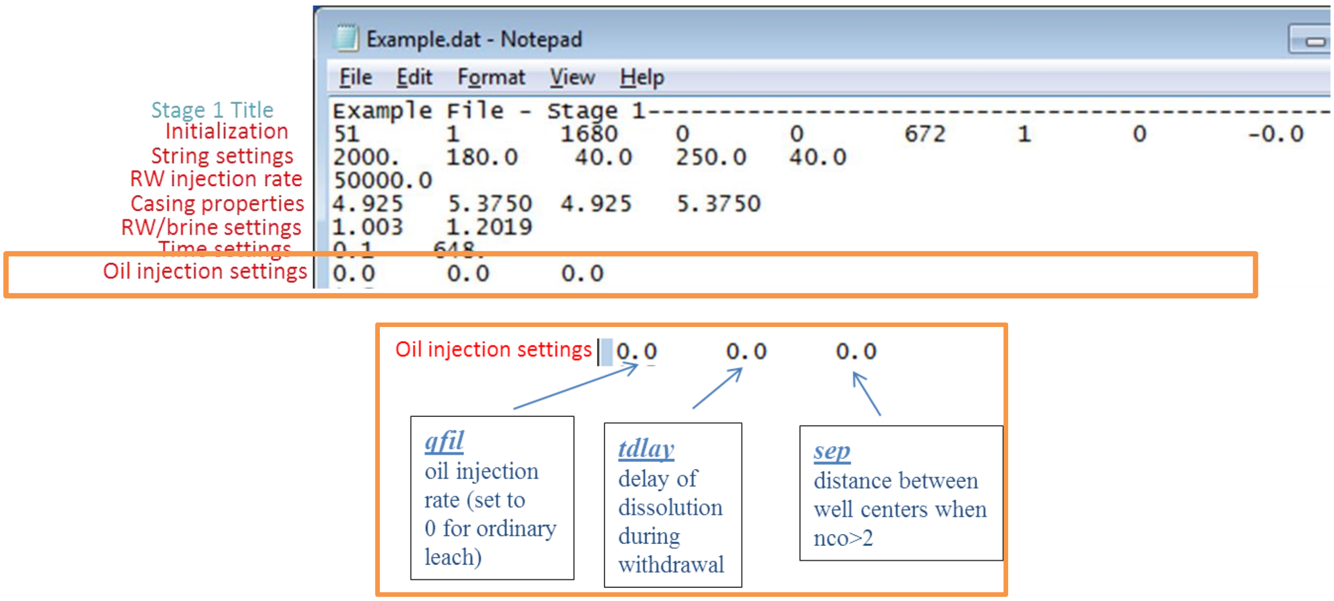


Figure 4-11. Oil Injection and Miscellaneous Settings Input Record.

qfil – Rate of oil injection in bbls/day. This is used for leach/fill operations (when ***leachType*** =2, described in section 4.1.2). For ordinary leach this variable is set to 0 within the code.

tdlay – The variable ***tdlay*** is no longer relevant for typical SPR operations and should be set to 0.0. Early in leach modeling at SPR there was some question as to whether there would be a delay in leaching potential after oil had been removed from all or part of the cavern. As oil acts as a protective layer against leaching (it was the traditional protective blanket material for brining operations) it was unknown if a layer of oil would remain in the cavern after the majority of oil had been removed. An experiment was conducted and it was found that no residual oil remained to hamper leaching and no delay occurred (Reda and Russo 1983).

sep – Distance in feet between wells when multiple cavities are to be leached during sump or initial cavern development (when ***nco*** > 1, section 4.1.2). Vertical sections of wells are assumed to have coalesced when the well radius exceeds **0.5*sep**.

4.1.9 Cavern Geometry Input Data Description

An example of simple axisymmetric geometry input data (stage 0 only) is provided in Figure 4-12. Actual data to be input and its format are dependent on the value of ***idata*** specified in section 4.1.2. Available options are summarized in Table 4-1. In the table, row 1 is the value of ***idata***. Subsequent rows (input records) list data to be input and format for each option, where *r* is cavern average radius (ft), *z* is depth (ft), *v* is cumulative cavern volume (bbls) measured from the roof. For ***idata*** = 0 the cavern average radius is specified from the bottom of the cavern up; Δz is assumed constant at ***zmax*/*ndiv***; and grid point positions, ***z***, are calculated by the code.

For non-zero ***idata***, more generalized geometry data can be specified for up to 500 grid points. Radius at the ***ndiv***+1 constant Δz grid-points assumed by the SANSMIC model will be determined by linear interpolation of the inputted grid data. Data can be listed from floor up or roof down (cumulative volume is still measured from the roof in either case) and SANSMIC will convert volumes to radii, if necessary, and orient the data properly. Originally, SANSMIC used cubic splines to interpolate the generalized input grid. The logic is still there, but an internal flag must be set to override the current linear interpolation default.

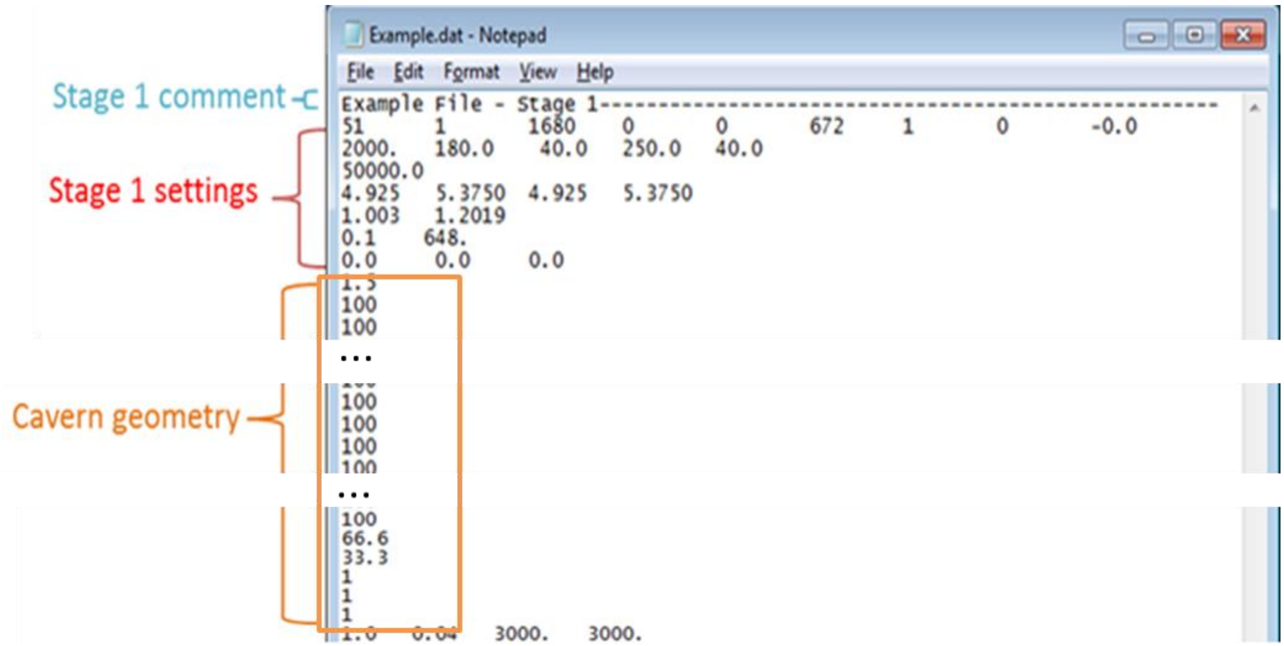


Figure 4-12. Cavern Geometry Input Details for *idata* = 0.

Table 4-1. Cavern Geometry Specification for the Different *idata* Options.

***idata* = 0**	**1**	**-1**		**2**	
r(1)	***ndata***	***ndata***		***ndata***	
r(2)	***z***(1)	***z***(1)	***v***(1)	***z*** (1)	***r***(1)
r(3)	***z***(2)	***z***(2)	***v***(2)	***z*** (2)	***r***(2)
…	***z***(3)	***z***(3)	***v***(2)	***z*** (3)	***r***(3)
r(***ndiv***)	…	…		…	
r(***ndiv***+1)	***z***(***ndata***)	***z***(***ndata***)	***v***(***ndata***)	***z***(***ndata***)	***r***(***ndata***)
	v(1)				
	v(2)				
	v(3)				
	…				
	v(***ndata***)				

4.1.10 Constant Parameters Input Record

This input data record (highlighted in Figure 4-13) is for input of parameters that do not change from stage to stage. It is included in the first stage only. Variables are annotated at the bottom of the figure and are detailed below.

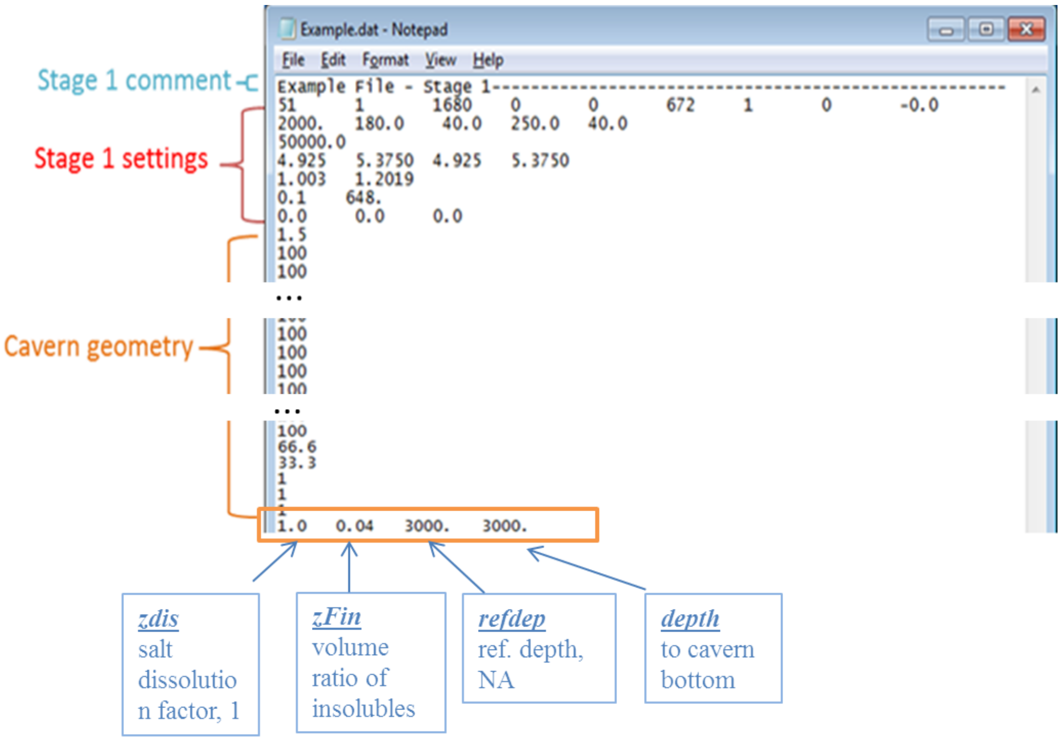


Figure 4-13. Constant Parameters Input Record Details.

zdis – Average salt dissolution factor (ratio of actual vertical wall dissolution rate to the model rate). Unless special salt characteristics are known, this value should be 1.

zFin – Average volume ratio of insolubles to salt. Typical values are 0.03 – 0.06.

refdep – Reference depth (not used).

depth – Depth to cavern bottom, in feet. ***depth*** – ***zmax*** = depth to top of cavern.

Page intentionally left blank.

5 Output Files

SANSMIC produces multiple output files differentiated by a filename extension appended to root of the input filename. Briefly:

***.log** – a run time log primarily containing an input data echo and input data processing information relevant for debugging.

***.out** – the primary results output file that contains snapshots of many model variables over the entire computational grid at user specified times and at the beginning and end of each stage and workover.

***.tst** – history data for several key simulation variables

***.rad** – cavern radius versus depth for all stages in a portable tabular format.

***.dra** – cavern change-in-radius versus depth for all stages in a portable tabular format.

***.dll** – initial cavern geometry and change in radius for all stages in a simulation in a portable tabular format. File was intended for use as an interface file for P2D, pillar-to-diameter, cavern stability software.

Subsequent sections provide detailed descriptions of each file.

5.1 *.*log* Output file Description

The ***.log*** file is the runtime log that documents the execution of the current simulation including error messages. The input file is first echoed line for line, then the interpretation of the data is recorded as it is read and processed. In this way, if an input record is unexpected or translated incorrectly, this should be evident in the log file. Certain common error statements are also printed to the log file to aid in detecting the location of the error in the input file. A screen shot of an example log file is shown in Figure 5-1. The left-hand side of the figure shows the line-by-line echo of the input file, while the right-had side shows the later portion of the log file in which the individual input variables are interpreted.

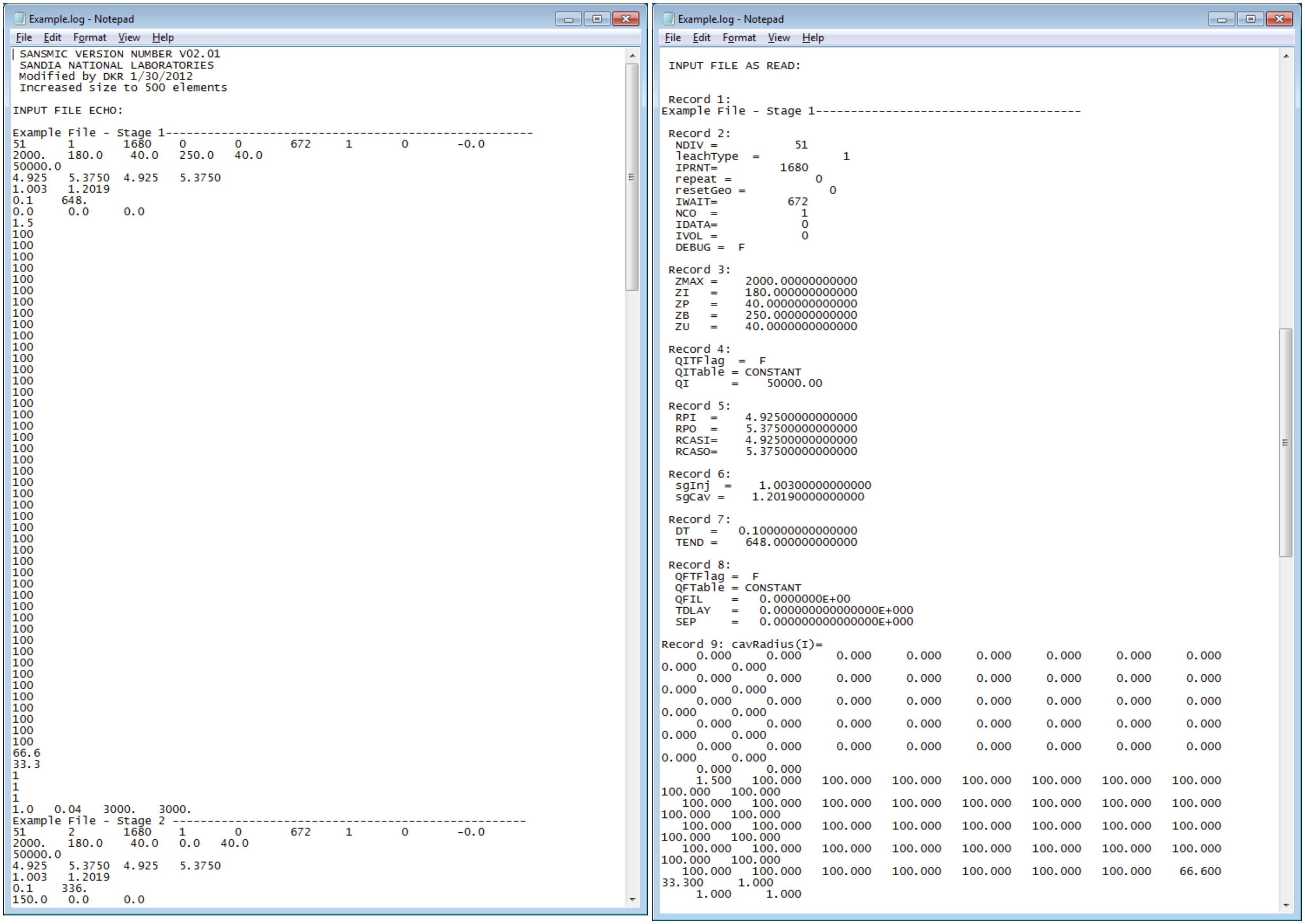
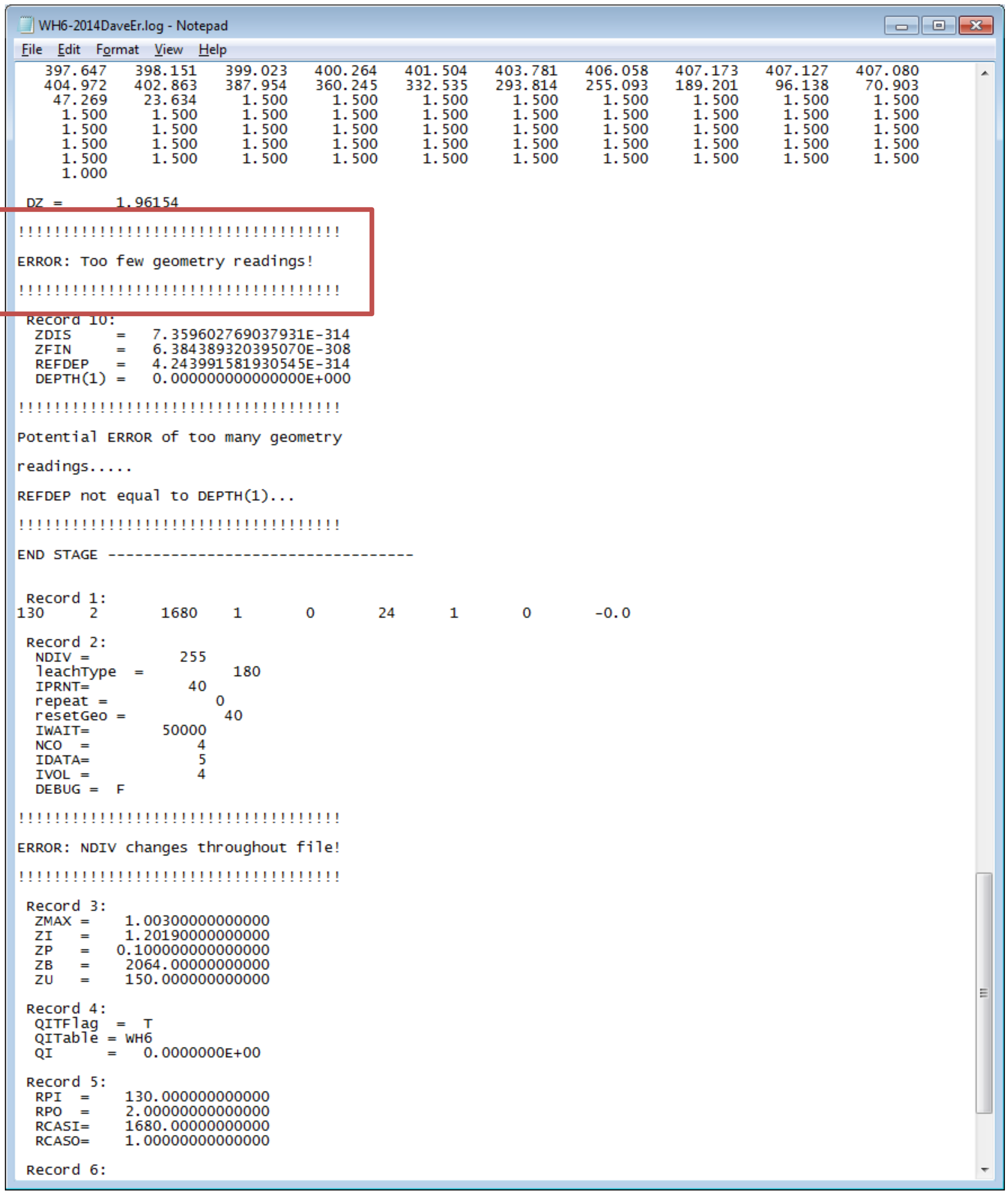

```
Example.log - Notepad
File Edit Format View Help
 SANSMIC VERSION NUMBER V02.01
 SANDIA NATIONAL LABORATORIES
 Modified by DKR 1/30/2012
 Increased size to 500 elements

INPUT FILE ECHO:

Example File - Stage 1-----------------------------------------------------------
51      1       1680     0        0        672     1        0        -0.0
2000.   180.0    40.0   250.0   40.0
50000.0
4.925   5.3750  4.925   5.3750
1.003   1.2019
0.1     648.
0.0     0.0     0.0
1.5
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
100
66.6
33.3
1
1
1
1.0   0.04   3000.   3000.
Example File - Stage 2 ----------------------------------------------------------
51      2       1680     1        0        672     1        0        -0.0
2000.   180.0    40.0   0.0   40.0
50000.0
4.925   5.3750  4.925   5.3750
1.003   1.2019
0.1     336.
150.0   0.0     0.0
```
```
Example.log - Notepad
File Edit Format View Help
 INPUT FILE AS READ:

 Record 1:
Example File - Stage 1--------------------------------------

 Record 2:
  NDIV =             51
  leachType  =             1
  IPRNT=           1680
  repeat =              0
  resetGeo =              0
  IWAIT=            672
  NCO  =              1
  IDATA=              0
  IVOL =              0
  DEBUG =  F

 Record 3:
  ZMAX =     2000.00000000000
  ZI   =     180.000000000000
  ZP   =     40.0000000000000
  ZB   =     250.000000000000
  ZU   =     40.0000000000000

 Record 4:
  QITFlag   =  F
  QITable = CONSTANT
  QI      =     50000.00

 Record 5:
  RPI  =     4.92500000000000
  RPO  =     5.37500000000000
  RCASI=     4.92500000000000
  RCASO=     5.37500000000000

 Record 6:
  sgInj  =     1.00300000000000
  sgCav =    1.20190000000000

 Record 7:
  DT   =   0.100000000000000
  TEND =     648.000000000000

 Record 8:
  QFTFlag =  F
  QFTable = CONSTANT
  QFIL    =     0.0000000E+00
  TDLAY   =     0.000000000000000E+000
  SEP     =     0.000000000000000E+000

Record 9: cavRadius(I)=
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
0.000     0.000
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
0.000     0.000
     0.000     0.000
     1.500   100.000   100.000   100.000   100.000   100.000   100.000   100.000
100.000   100.000
   100.000   100.000   100.000   100.000   100.000   100.000   100.000   100.000
100.000   100.000
   100.000   100.000   100.000   100.000   100.000   100.000   100.000   100.000
100.000   100.000
   100.000   100.000   100.000   100.000   100.000   100.000   100.000   100.000
100.000   100.000
   100.000   100.000   100.000   100.000   100.000   100.000   100.000    66.600
33.300     1.000
     1.000     1.000
```

Figure 5-1. Example of the Log Output File.

Figure 5-2 shows an example of a log file in which an error has been detected in the input file. The error is highlighted in red. The log file also states two more potential errors, but in this case, the first is the only true error as subsequent errors were caused by the first. In some cases, a specific error statement is not given, but the log file terminates prior to the end of the input processing. The last printed input record likely precedes the input record with an error.


WH6-2014DaveEr.log - Notepad

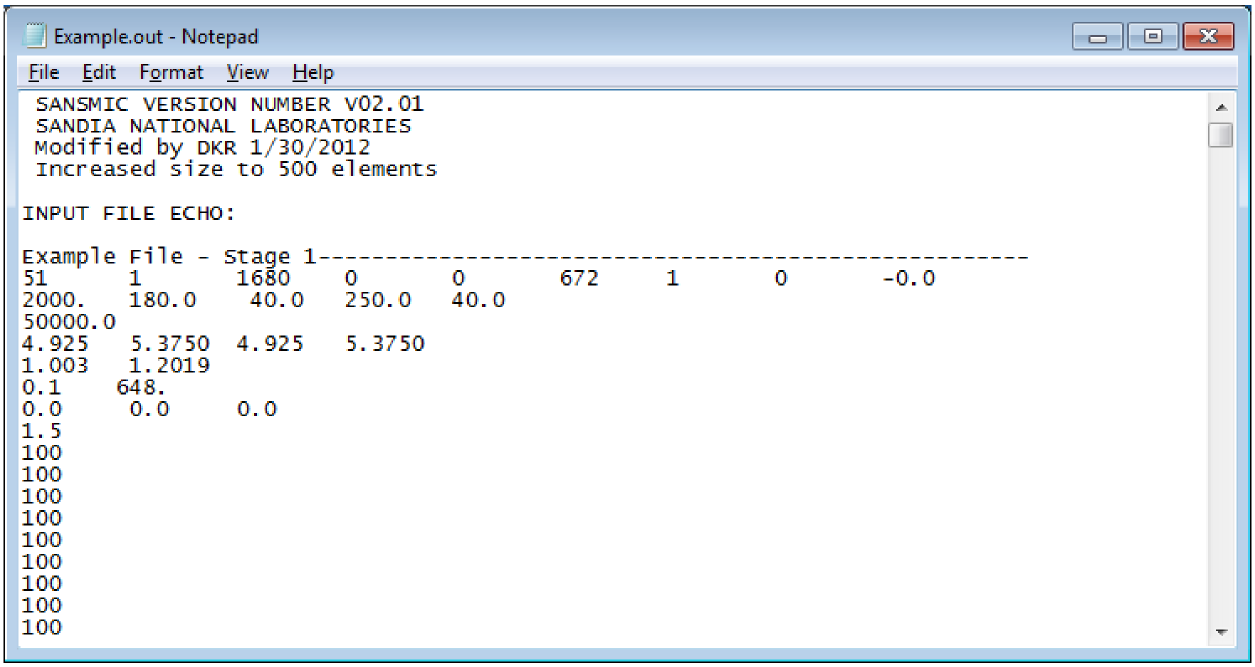
File Edit Format View Help

```
   397.647    398.151    399.023    400.264    401.504    403.781    406.058    407.173    407.127    407.080
   404.972    402.863    387.954    360.245    332.535    293.814    255.093    189.201     96.138     70.903
    47.269     23.634      1.500      1.500      1.500      1.500      1.500      1.500      1.500      1.500
     1.500      1.500      1.500      1.500      1.500      1.500      1.500      1.500      1.500      1.500
     1.500      1.500      1.500      1.500      1.500      1.500      1.500      1.500      1.500      1.500
     1.500      1.500      1.500      1.500      1.500      1.500      1.500      1.500      1.500      1.500
     1.500      1.500      1.500      1.500      1.500      1.500      1.500      1.500      1.500      1.500
     1.000

 DZ =       1.96154
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

ERROR: Too few geometry readings!

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 Record 10:
  ZDIS      =    7.359602769037931E-314
  ZFIN      =    6.384389320395070E-308
  REFDEP    =    4.243991581930545E-314
  DEPTH(1) =    0.000000000000000E+000

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

Potential ERROR of too many geometry

readings.....

REFDEP not equal to DEPTH(1)...

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

END STAGE ----------------------------------


 Record 1:
130      2       1680    1       0       24      1       0       -0.0

 Record 2:
  NDIV =           255
  leachType  =           180
  IPRNT=            40
  repeat =            0
  resetGeo =           40
  IWAIT=         50000
  NCO   =             4
  IDATA=             5
  IVOL  =             4
  DEBUG =   F

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

ERROR: NDIV changes throughout file!

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

 Record 3:
  ZMAX =     1.00300000000000
  ZI   =     1.20190000000000
  ZP   =    0.100000000000000
  ZB   =     2064.00000000000
  ZU   =     150.000000000000

 Record 4:
  QITFlag   =  T
  QITable = WH6
  QI         =    0.0000000E+00

 Record 5:
  RPI  =     130.000000000000
  RPO  =     2.00000000000000
  RCASI=     1680.00000000000
  RCASO=     1.00000000000000

 Record 6:
```

Figure 5-2. Example of a Log File When an Error Has Occurred.

5.2 *.*out* Output File Description

The ***.out*** file contains the primary output and model debug data and is the largest, most verbose of the SANSMIC output files. The file contains a snapshot of many computational variables over the entire grid at specified times. The file can be used to monitor the internal workings of the model. The beginning of the ***.out*** file is shown in Figure 5-3 where one can see the standard code header followed by an echo of the input file. This is followed by blocks of output grid data at specified times; one such data dump block is shown in Figure 5-4. An annotated version of the left-half of the ***.out*** file is provided in Figure 5-5. An annotated version of the right-half of the ***.out*** file is provided in Figure 5-6. Details of each annotated section and variables follow the figures.




```
 SANSMIC VERSION NUMBER V02.01
 SANDIA NATIONAL LABORATORIES
 Modified by DKR 1/30/2012
 Increased size to 500 elements

INPUT FILE ECHO:

Example File - Stage 1-----------------------------------------------------
51      1       1680    0       0       672     1       0       -0.0
2000.   180.0    40.0   250.0   40.0
50000.0
4.925   5.3750  4.925   5.3750
1.003   1.2019
0.1    648.
0.0     0.0     0.0
1.5
100
100
100
100
100
100
100
100
100
```

Figure 5-3. Example of the Beginning of a *.out* Output File.

Example.out - Notepad

File Edit Format View Help

TIME= 4.1667E-03 DAYS (1.0000E-01 HRS)   DT= 1.0000E-01 HOURS   START TIME= 0.0000E+00 DAYS (0.0000E+00 HRS)
INJECTION PHASE   1

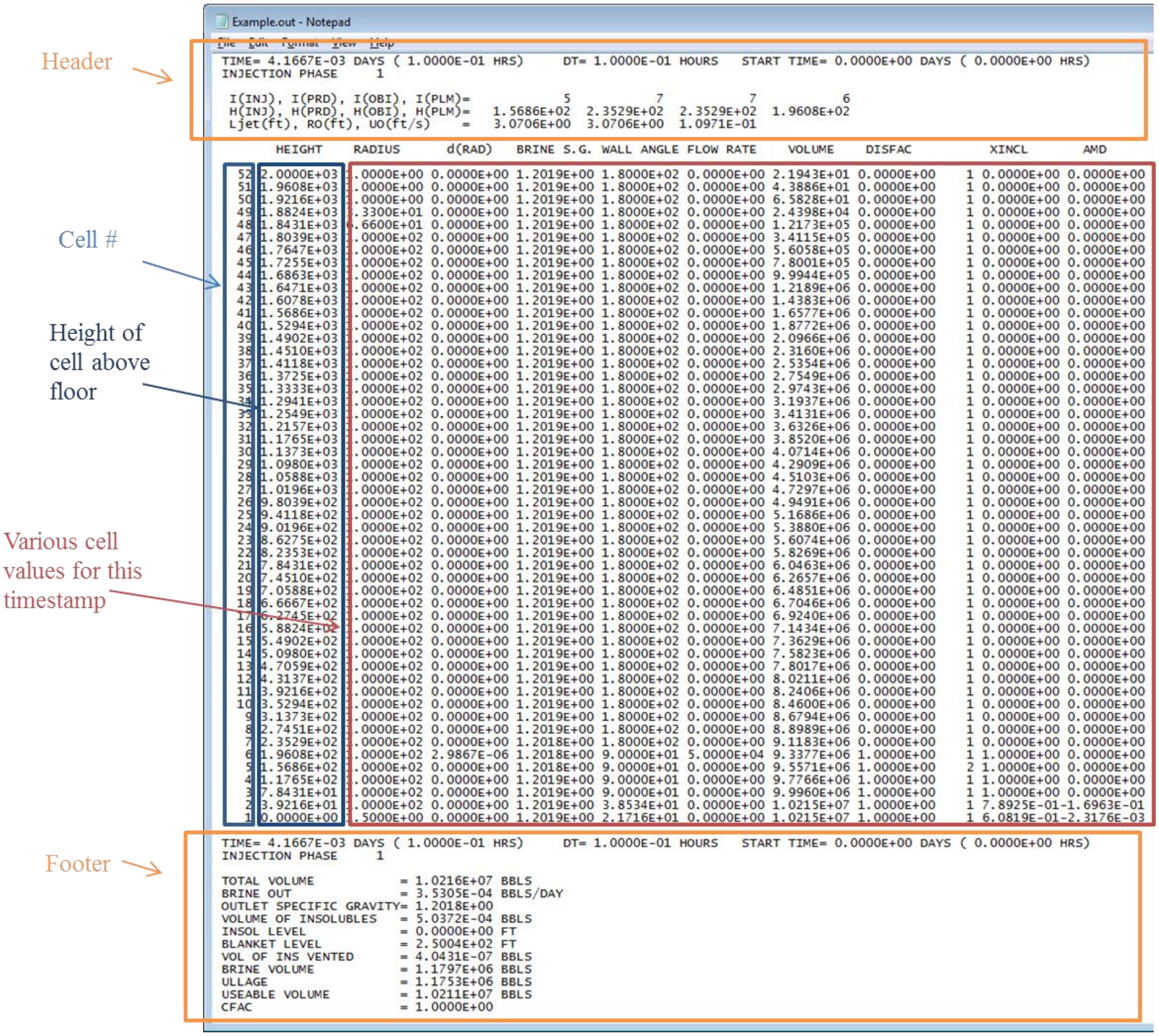
I(INJ), I(PRD), I(OBI), I(PLM)=   5   7   7   6
H(INJ), H(PRD), H(OBI), H(PLM)=   1.5686E+02 2.3529E+02 2.3529E+02 1.9608E+02
Ljet(ft), RO(ft), UO(ft/s)   =   3.0706E+00 3.0706E+00 1.0971E-01

	HEIGHT	RADIUS	d(RAD)	BRINE S.G.	WALL ANGLE	FLOW RATE	VOLUME	DISFAC		XINCL	AMD	AKD	dc/dz	Cold	Cnew	dC	dR	Cplm	Uplm	Rplm
52	2.0000E+03	1.0000E+00	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	2.1943E+01	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
51	1.9608E+03	1.0000E+00	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	4.3886E+01	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
50	1.9216E+03	1.0000E+00	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	6.5828E+01	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
49	1.8824E+03	3.3300E+01	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	2.4398E+04	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
48	1.8431E+03	6.6600E+01	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	1.2173E+05	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
47	1.8039E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	3.4115E+05	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
46	1.7647E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	5.6058E+05	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
45	1.7255E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	7.8001E+05	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
44	1.6863E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	9.9944E+05	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
43	1.6471E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	1.2189E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
42	1.6078E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	1.4383E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
41	1.5686E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	1.6577E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
40	1.5294E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	1.8772E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
39	1.4902E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	2.0966E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
38	1.4510E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	2.3160E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
37	1.4118E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	2.5354E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
36	1.3725E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	2.7549E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
35	1.3333E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	2.9743E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
34	1.2941E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	3.1937E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
33	1.2549E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	3.4131E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
32	1.2157E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	3.6326E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
31	1.1765E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	3.8520E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
30	1.1373E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	4.0714E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
29	1.0980E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	4.2909E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
28	1.0588E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	4.5103E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
27	1.0196E+03	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	4.7297E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
26	9.8039E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	4.9491E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
25	9.4118E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	5.1686E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
24	9.0196E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	5.3880E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
23	8.6275E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	5.6074E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
22	8.2353E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	5.8269E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
21	7.8431E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	6.0463E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
20	7.4510E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	6.2657E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
19	7.0588E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	6.4851E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
18	6.6667E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	6.7046E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
17	6.2745E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	6.9240E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
16	5.8824E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	7.1434E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
15	5.4902E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	7.3629E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
14	5.0980E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	7.5823E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
13	4.7059E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	7.8017E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
12	4.3137E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	8.0211E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
11	3.9216E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	8.2406E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
10	3.5294E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	8.4600E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
9	3.1373E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	8.6794E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
8	2.7451E+02	1.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	8.8989E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
7	2.3529E+02	1.0000E+02	0.0000E+00	1.2018E+00	1.8000E+02	0.0000E+00	9.1183E+06	0.0000E+00	1	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	1.2018E+00	1.2018E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6	1.9608E+02	1.0000E+02	2.9867E-06	1.2018E+00	9.0000E+01	5.0000E+04	9.3377E+06	1.0000E+00	1	1.0000E+00	0.0000E+00	5.0300E-05	0.0000E+00	1.2018E+00	1.2018E+00	3.5527E-15	2.8718E-06	1.1918E+00	3.3352E+00	2.4719E+00
5	1.5686E+02	1.0000E+02	0.0000E+00	1.2018E+00	9.0000E+01	0.0000E+00	9.5571E+06	1.0000E+00	2	1.0000E+00	0.0000E+00	5.0300E-05	0.0000E+00	1.2019E+00	1.2018E+00	-5.6984E-05	0.0000E+00	1.1881E+00	3.5476E+00	2.0493E+00
4	1.1765E+02	1.0000E+02	0.0000E+00	1.2019E+00	9.0000E+01	0.0000E+00	9.7766E+06	1.0000E+00	1	1.0000E+00	0.0000E+00	5.0300E-05	0.0000E+00	1.2019E+00	1.2019E+00	-1.8696E-13	0.0000E+00	1.0030E+00	1.0971E-01	3.0706E+00
3	7.8431E+01	1.0000E+02	0.0000E+00	1.2019E+00	9.0000E+01	0.0000E+00	9.9960E+06	1.0000E+00	1	1.0000E+00	0.0000E+00	5.0300E-05	0.0000E+00	1.2019E+00	1.2019E+00	-2.2204E-16	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2	3.9216E+01	1.0000E+02	0.0000E+00	1.2019E+00	3.8534E+01	0.0000E+00	1.0215E+07	1.0000E+00	1	7.8925E-01	-1.6963E-01	5.0300E-05	0.0000E+00	1.2019E+00	1.2019E+00	-2.2204E-16	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1	0.0000E+00	1.5000E+00	0.0000E+00	1.2019E+00	2.1716E+01	0.0000E+00	1.0215E+07	1.0000E+00	1	6.0819E-01	-2.3176E-03	5.0300E-05	0.0000E+00	1.2019E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

TIME= 4.1667E-03 DAYS (1.0000E-01 HRS)   DT= 1.0000E-01 HOURS   START TIME= 0.0000E+00 DAYS (0.0000E+00 HRS)
INJECTION PHASE   1

TOTAL VOLUME = 1.0216E+07 BBLS
BRINE OUT = 3.5305E-04 BBLS/DAY
OUTLET SPECIFIC GRAVITY= 1.2018E+00
VOLUME OF INSOLUBLES = 5.0372E-04 BBLS
INSOL LEVEL = 0.0000E+00 FT
BLANKET LEVEL = 2.5004E+02 FT
VOL OF INS VENTED = 4.0431E-07 BBLS
BRINE VOLUME = 1.1797E+06 BBLS
ULLAGE = 1.1753E+06 BBLS
USEABLE VOLUME = 1.0211E+07 BBLS
CFAC = 1.0000E+00

Figure 5-4. Example of a *.out* Output File Grid Data Block.



TIME= 4.1667E-03 DAYS (1.0000E-01 HRS)   DT= 1.0000E-01 HOURS   START TIME= 0.0000E+00 DAYS (0.0000E+00 HRS)
INJECTION PHASE   1

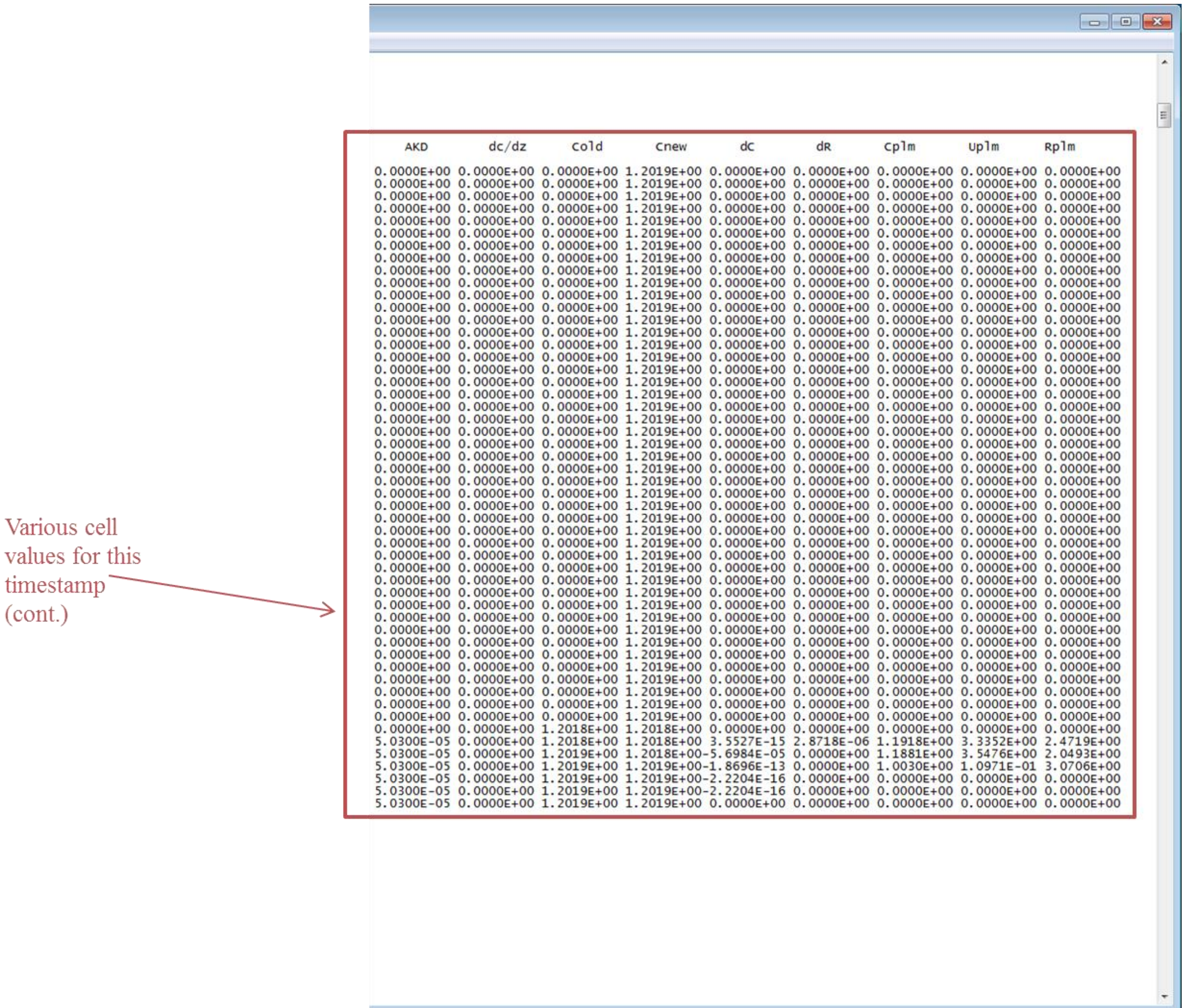
I(INJ), I(PRD), I(OBI), I(PLM)= 5 7 7 6
H(INJ), H(PRD), H(OBI), H(PLM)= 1.5686E+02 2.3529E+02 2.3529E+02 1.9608E+02
Ljet(ft), RO(ft), UO(ft/s)   = 3.0706E+00 3.0706E+00 1.0971E-01

	HEIGHT	RADIUS	d(RAD)	BRINE S.G.	WALL ANGLE	FLOW RATE	VOLUME	DISFAC		XINCL	AMD
52	2.0000E+03	.0000E+00	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	2.1943E+01	0.0000E+00	1	0.0000E+00	0.0000E+00
51	1.9608E+03	.0000E+00	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	4.3886E+01	0.0000E+00	1	0.0000E+00	0.0000E+00
50	1.9216E+03	.0000E+00	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	6.5828E+01	0.0000E+00	1	0.0000E+00	0.0000E+00
49	1.8824E+03	.3300E+01	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	2.4398E+04	0.0000E+00	1	0.0000E+00	0.0000E+00
48	1.8431E+03	.6600E+01	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	1.2173E+05	0.0000E+00	1	0.0000E+00	0.0000E+00
47	1.8039E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	3.4115E+05	0.0000E+00	1	0.0000E+00	0.0000E+00
46	1.7647E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	5.6058E+05	0.0000E+00	1	0.0000E+00	0.0000E+00
45	1.7255E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	7.8001E+05	0.0000E+00	1	0.0000E+00	0.0000E+00
44	1.6863E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	9.9944E+05	0.0000E+00	1	0.0000E+00	0.0000E+00
43	1.6471E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	1.2189E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
42	1.6078E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	1.4383E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
41	1.5686E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	1.6577E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
40	1.5294E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	1.8772E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
39	1.4902E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	2.0966E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
38	1.4510E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	2.3160E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
37	1.4118E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	2.5354E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
36	1.3725E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	2.7549E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
35	1.3333E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	2.9743E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
34	1.2941E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	3.1937E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
33	1.2549E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	3.4131E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
32	1.2157E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	3.6326E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
31	1.1765E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	3.8520E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
30	1.1373E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	4.0714E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
29	1.0980E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	4.2909E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
28	1.0588E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	4.5103E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
27	1.0196E+03	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	4.7297E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
26	9.8039E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	4.9491E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
25	9.4118E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	5.1686E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
24	9.0196E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	5.3880E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
23	8.6275E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	5.6074E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
22	8.2353E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	5.8269E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
21	7.8431E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	6.0463E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
20	7.4510E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	6.2657E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
19	7.0588E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	6.4851E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
18	6.6667E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	6.7046E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
17	6.2745E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	6.9240E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
16	5.8824E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	7.1434E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
15	5.4902E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	7.3629E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
14	5.0980E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	7.5823E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
13	4.7059E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	7.8017E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
12	4.3137E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	8.0211E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
11	3.9216E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	8.2406E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
10	3.5294E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	8.4600E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
9	3.1373E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	8.6794E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
8	2.7451E+02	.0000E+02	0.0000E+00	1.2019E+00	1.8000E+02	0.0000E+00	8.8989E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
7	2.3529E+02	.0000E+02	0.0000E+00	1.2018E+00	1.8000E+02	0.0000E+00	9.1183E+06	0.0000E+00	1	0.0000E+00	0.0000E+00
6	1.9608E+02	.0000E+02	2.9867E-06	1.2018E+00	9.0000E+01	5.0000E+04	9.3377E+06	1.0000E+00	1	1.0000E+00	0.0000E+00
5	1.5686E+02	.0000E+02	0.0000E+00	1.2018E+00	9.0000E+01	0.0000E+00	9.5571E+06	1.0000E+00	2	1.0000E+00	0.0000E+00
4	1.1765E+02	.0000E+02	0.0000E+00	1.2019E+00	9.0000E+01	0.0000E+00	9.7766E+06	1.0000E+00	1	1.0000E+00	0.0000E+00
3	7.8431E+01	.0000E+02	0.0000E+00	1.2019E+00	9.0000E+01	0.0000E+00	9.9960E+06	1.0000E+00	1	1.0000E+00	0.0000E+00
2	3.9216E+01	.0000E+02	0.0000E+00	1.2019E+00	3.8534E+01	0.0000E+00	1.0215E+07	1.0000E+00	1	7.8925E-01	-1.6963E-01
1	0.0000E+00	.5000E+00	0.0000E+00	1.2019E+00	2.1716E+01	0.0000E+00	1.0215E+07	1.0000E+00	1	6.0819E-01	-2.3176E-03

TIME= 4.1667E-03 DAYS (1.0000E-01 HRS)   DT= 1.0000E-01 HOURS   START TIME= 0.0000E+00 DAYS (0.0000E+00 HRS)
INJECTION PHASE   1

TOTAL VOLUME = 1.0216E+07 BBLS
BRINE OUT = 3.5305E-04 BBLS/DAY
OUTLET SPECIFIC GRAVITY= 1.2018E+00
VOLUME OF INSOLUBLES = 5.0372E-04 BBLS
INSOL LEVEL = 0.0000E+00 FT
BLANKET LEVEL = 2.5004E+02 FT
VOL OF INS VENTED = 4.0431E-07 BBLS
BRINE VOLUME = 1.1797E+06 BBLS
ULLAGE = 1.1753E+06 BBLS
USEABLE VOLUME = 1.0211E+07 BBLS
CFAC = 1.0000E+00

Figure 5-5. Annotated *.out* Output File – Left Half.



AKD	dc/dz	Cold	Cnew	dC	dR	Cplm	Uplm	Rplm
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	0.0000E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.0000E+00	0.0000E+00	1.2018E+00	1.2018E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5.0300E-05	0.0000E+00	1.2018E+00	1.2018E+00	3.5527E-15	2.8718E-06	1.1918E+00	3.3352E+00	2.4719E+00
5.0300E-05	0.0000E+00	1.2019E+00	1.2018E+00	-5.6984E-05	0.0000E+00	1.1881E+00	3.5476E+00	2.0493E+00
5.0300E-05	0.0000E+00	1.2019E+00	1.2019E+00	-1.8696E-13	0.0000E+00	1.0030E+00	1.0971E-01	3.0706E+00
5.0300E-05	0.0000E+00	1.2019E+00	1.2019E+00	-2.2204E-16	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5.0300E-05	0.0000E+00	1.2019E+00	1.2019E+00	-2.2204E-16	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5.0300E-05	0.0000E+00	1.2019E+00	1.2019E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

Figure 5-6. Annotated *.out* Output File – Right Half.

Header – • The time of the output data, time step size, and the start time of the current stage.
- Type of phase (injection or workover) and the stage number.
- Cell location for the injection, production, OBI, and plume cell, respectively
- Height above the cavern floor of the same variables,
- Jet length, and initial radius and velocity of the plume.

Cell # – Each grid point, numbered from the bottom of the cavern up, is given vertically, but here the columns are variable values associated with the current time (described below).

Height – Height above initial cavern floor, in feet,

Radius – Radius, in feet,

D(rad) – Cumulative change in radius, in feet.

Brine S.G – Specific gravity of the brine. A value of 1.2019 is considered saturated. When a cell is occupied by oil the value is set to 1.2019 as a flag so that no leaching will occur in this cell.

Wall Angle– The wall angle, in degrees. Described in detail in Section 2.3 of Weber and Rudeen (2015).

Flow Rate – Brine flow rate in barrels per day. Section of the cavern experiencing flow is dependent on string positions.

Volume – The cumulative volume of the cavern (starting from the roof), in bbls.

Disfac – The value of the dissolution adjustment factor is determined by a combination of factors including type of leach (direct or reverse), wall angle, temperature, and others as described in Chapter 4 of Weber and Rudeen (2015).

Unlabeled column. – Dissolution adjustment factor type flag:

- 0 – Default dissolution adjustment
- 1 – Temperature adjustment
- 2 – Insolubles geometry factor
- 3 – Direct leach velocity correction
- 4 – Top-inject leach, no adjustment
- 51 – Top-inject leach, upper region
- 52 – Top-inject leach, lower region

Xincl – Wall Inclination dissolution factor described in Chapter 4 of Weber and Rudeen (2015).

Amd – Internal variable used for debugging.

Akd – Diffusion coefficient (or diffCoef within the code) described in Section 2.2 of Weber and Rudeen (2015).

dC/dz – Change in specific gravity (or brine concentration gradient) from one cell to the next. See Weber and Rudeen (2015).

Cold – Previous calculated value of specific gravity (C_{old} or C_i^{n-1}).

Cnew – Current calculated value of specific gravity (C_{new} or C_i^n).

dC – $C_{new} – C_{old}$

dR Wall recession

Cplm – Brine concentration of the plume – see Section 2.6 of Weber and Rudeen (2015).

Uplm – Velocity of the plume.

Rplm – Radius of the plume.

The Footer section, visible is left half of *.out* file (Figure 5-5), contains some of the same time and stage data from the header including:

- Current timestamp
- Time step size
- Start time
- Phase type (injection or workover)
- Stage number

This is followed by self-described variables that are representative of the cavern as a whole, including:

- Total volume of the cavern
- Rate of produced brine
- Specific gravity of the produced brine
- Volume of insoluble that has collected since the simulation began
- Depth of the OBI
- Volume of insolubles that have been produced
- Volume of the brine
- Ullage volume, the volume usable for oil storage
- Variable ***CFAC*** is a mass balance correction factor used to determine if the solution algorithm is operating correctly. The further away from 1.0, the worse the code is performing. If ***CFAC*** is not very close to 1.0, rerun the simulation with smaller time step.

5.3 *.*tst* Output File Description

The .***tst*** output file can be thought of as the (time) history output data file as it gives information in roughly one day increments for the cavern as a whole or as an average. An example of a .***tst*** file is shown in Figure 5-7. The upper left-half of the file is repeated in Figure 5-8 with annotations. The upper right-half of the file is repeated in Figure 5-9 with annotations. Details of the annotations follow the figures.

Example.tst - Notepad

File Edit Format View Help

File= Example

TIME Days	TOT. VOL Bbls	CFAC	OUTLET S.G.	SGave	INSOL VOL bbl	INSOL Depth feet	OBI Depth Feet	INSOL.VNT Bbls	ULLAGE Bbls	ZUVOL BBL	QI BPD	QITOT BBL	QFIL BPD	QFILTOT BBL
4.1667E-03	1.0216E+07	1.0000E+00	1.2018E+00	1.2019E+00	5.0372E-04	3.0000E+03	2.7500E+03	4.0431E-07	1.1753E+06	1.0211E+07	2.0833E+02	2.0833E+02	0.0000E+00	0.0000E+00
1.0000E+00	1.0216E+07	9.9998E-01	1.1863E+00	1.1941E+00	7.3248E+00	2.9942E+03	2.7412E+03	2.1311E-03	1.2245E+06	1.0211E+07	4.9792E+04	5.0000E+04	-4.9112E+04	-4.9112E+04
2.0042E+00	1.0216E+07	9.9998E-01	1.1739E+00	1.1879E+00	3.2927E+01	2.9738E+03	2.7323E+03	8.9887E-03	1.2747E+06	1.0212E+07	5.0208E+04	1.0021E+05	-4.9494E+04	-9.8607E+04
3.0041E+00	1.0217E+07	9.9999E-01	1.1642E+00	1.1830E+00	7.6068E+01	2.9608E+03	2.7236E+03	2.0575E-02	1.3250E+06	1.0213E+07	5.0000E+04	1.5021E+05	-4.9244E+04	-1.4785E+05
4.0041E+00	1.0219E+07	9.9999E-01	1.1563E+00	1.1791E+00	1.3532E+02	2.9608E+03	2.7148E+03	3.6482E-02	1.3758E+06	1.0215E+07	5.0000E+04	2.0021E+05	-4.9195E+04	-1.9705E+05
5.0041E+00	1.0221E+07	9.9999E-01	1.1501E+00	1.1760E+00	2.0868E+02	2.9608E+03	2.7060E+03	5.6139E-02	1.4268E+06	1.0217E+07	5.0000E+04	2.5021E+05	-4.9146E+04	-2.4619E+05
6.0041E+00	1.0224E+07	9.9999E-01	1.1460E+00	1.1700E+00	3.1932E+02	2.9607E+03	2.6972E+03	7.8946E-02	1.4784E+06	1.0219E+07	5.0000E+04	3.0021E+05	-4.9011E+04	-2.9520E+05
7.0000E+00	1.0227E+07	9.9999E-01	1.1431E+00	1.1683E+00	4.3996E+02	2.9607E+03	2.6886E+03	1.0347E-01	1.5302E+06	1.0223E+07	4.9792E+04	3.5000E+05	-4.8764E+04	-3.4397E+05
8.0001E+00	1.0230E+07	9.9999E-01	1.1405E+00	1.1668E+00	5.6927E+02	2.9607E+03	2.6798E+03	1.2967E-01	1.5825E+06	1.0226E+07	5.0000E+04	4.0000E+05	-4.8933E+04	-3.9290E+05
9.0002E+00	1.0233E+07	9.9999E-01	1.1384E+00	1.1656E+00	7.0606E+02	2.9607E+03	2.6711E+03	1.5729E-01	1.6350E+06	1.0230E+07	5.0000E+04	4.5000E+05	-4.8901E+04	-4.4180E+05
1.0000E+01	1.0237E+07	9.9999E-01	1.1371E+00	1.1614E+00	8.6539E+02	2.9606E+03	2.6624E+03	1.8621E-01	1.6877E+06	1.0234E+07	5.0000E+04	5.0000E+05	-4.8808E+04	-4.9061E+05
1.1000E+01	1.0242E+07	9.9999E-01	1.1367E+00	1.1612E+00	1.0447E+03	2.9606E+03	2.6537E+03	2.1551E-01	1.7409E+06	1.0238E+07	5.0000E+04	5.5000E+05	-4.8726E+04	-5.3934E+05
1.2000E+01	1.0246E+07	9.9999E-01	1.1365E+00	1.1610E+00	1.2254E+03	2.9606E+03	2.6450E+03	2.4492E-01	1.7942E+06	1.0243E+07	5.0000E+04	6.0000E+05	-4.8720E+04	-5.8806E+05
1.3000E+01	1.0251E+07	9.9999E-01	1.1360E+00	1.1607E+00	1.4078E+03	2.9605E+03	2.6363E+03	2.7449E-01	1.8477E+06	1.0248E+07	5.0000E+04	6.5000E+05	-4.8712E+04	-6.3677E+05
1.4000E+01	1.0255E+07	9.9999E-01	1.1357E+00	1.1605E+00	1.5922E+03	2.9605E+03	2.6276E+03	3.0425E-01	1.9012E+06	1.0253E+07	5.0000E+04	7.0000E+05	-4.8703E+04	-6.8547E+05
1.5001E+01	1.0261E+07	9.9999E-01	1.1362E+00	1.1581E+00	1.8105E+03	2.9605E+03	2.6190E+03	3.3428E-01	1.9551E+06	1.0258E+07	5.0000E+04	7.5000E+05	-4.8561E+04	-7.3403E+05
1.6001E+01	1.0266E+07	9.9999E-01	1.1369E+00	1.1586E+00	2.0272E+03	2.9604E+03	2.6103E+03	3.6375E-01	2.0091E+06	1.0264E+07	5.0000E+04	8.0000E+05	-4.8569E+04	-7.8260E+05
1.7001E+01	1.0272E+07	9.9999E-01	1.1373E+00	1.1588E+00	2.2417E+03	2.9604E+03	2.6017E+03	3.9281E-01	2.0633E+06	1.0269E+07	5.0000E+04	8.5000E+05	-4.8580E+04	-8.3118E+05
1.8001E+01	1.0277E+07	9.9999E-01	1.1375E+00	1.1590E+00	2.4553E+03	2.9604E+03	2.5930E+03	4.2163E-01	2.1174E+06	1.0275E+07	5.0000E+04	9.0000E+05	-4.8585E+04	-8.7977E+05
1.9001E+01	1.0283E+07	9.9999E-01	1.1381E+00	1.1572E+00	2.6828E+03	2.9603E+03	2.5843E+03	4.5032E-01	2.1717E+06	1.0281E+07	5.0000E+04	9.5000E+05	-4.8527E+04	-9.2829E+05
2.0001E+01	1.0289E+07	9.9999E-01	1.1390E+00	1.1578E+00	2.9248E+03	2.9603E+03	2.5757E+03	4.7860E-01	2.2262E+06	1.0287E+07	5.0000E+04	1.0000E+06	-4.8467E+04	-9.7676E+05
2.1001E+01	1.0295E+07	9.9999E-01	1.1398E+00	1.1584E+00	3.1626E+03	2.9602E+03	2.5671E+03	5.0628E-01	2.2808E+06	1.0293E+07	5.0000E+04	1.0500E+06	-4.8488E+04	-1.0252E+06
2.2001E+01	1.0301E+07	9.9999E-01	1.1403E+00	1.1588E+00	3.3974E+03	2.9602E+03	2.5584E+03	5.3351E-01	2.3354E+06	1.0299E+07	5.0000E+04	1.1000E+06	-4.8502E+04	-1.0738E+06
2.3001E+01	1.0306E+07	9.9999E-01	1.1408E+00	1.1591E+00	3.6301E+03	2.9601E+03	2.5497E+03	5.6040E-01	2.3900E+06	1.0306E+07	5.0000E+04	1.1500E+06	-4.8512E+04	-1.1223E+06
2.4000E+01	1.0313E+07	9.9999E-01	1.1417E+00	1.1581E+00	3.8878E+03	2.9601E+03	2.5411E+03	5.8704E-01	2.4448E+06	1.0312E+07	5.0000E+04	1.2000E+06	-4.8409E+04	-1.1707E+06
2.5000E+01	1.0319E+07	9.9999E-01	1.1426E+00	1.1588E+00	4.1431E+03	2.9601E+03	2.5325E+03	6.1310E-01	2.4997E+06	1.0319E+07	5.0000E+04	1.2500E+06	-4.8421E+04	-1.2191E+06
2.6004E+01	1.0325E+07	9.9999E-01	1.1433E+00	1.1593E+00	4.3949E+03	2.9600E+03	2.5238E+03	6.3871E-01	2.5549E+06	1.0325E+07	5.0208E+04	1.3002E+06	-4.8645E+04	-1.2677E+06
2.7000E+01	1.0332E+07	9.9999E-01	1.1438E+00	1.1597E+00	4.6415E+03	2.9600E+03	2.5152E+03	6.6371E-01	2.6096E+06	1.0332E+07	4.9792E+04	1.3500E+06	-4.8255E+04	-1.3160E+06
													--- WO 1	
2.8003E+01	1.0338E+07	1.0000E+00	1.1475E+00	1.1623E+00	4.8782E+03	2.9599E+03	2.5154E+03	6.6371E-01	2.6147E+06	1.0338E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
2.9003E+01	1.0343E+07	1.0000E+00	1.1508E+00	1.1648E+00	5.0943E+03	2.9599E+03	2.5156E+03	6.6371E-01	2.6194E+06	1.0344E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
3.0003E+01	1.0348E+07	1.0000E+00	1.1539E+00	1.1670E+00	5.2928E+03	2.9598E+03	2.5157E+03	6.6371E-01	2.6237E+06	1.0349E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
3.1003E+01	1.0352E+07	1.0000E+00	1.1566E+00	1.1690E+00	5.4757E+03	2.9598E+03	2.5158E+03	6.6371E-01	2.6277E+06	1.0354E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
3.2002E+01	1.0357E+07	1.0000E+00	1.1592E+00	1.1708E+00	5.6446E+03	2.9598E+03	2.5160E+03	6.6371E-01	2.6314E+06	1.0358E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
3.3002E+01	1.0361E+07	1.0000E+00	1.1616E+00	1.1726E+00	5.8009E+03	2.9598E+03	2.5161E+03	6.6371E-01	2.6348E+06	1.0362E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
3.4002E+01	1.0364E+07	1.0000E+00	1.1637E+00	1.1741E+00	5.9458E+03	2.9597E+03	2.5162E+03	6.6371E-01	2.6380E+06	1.0366E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
3.5002E+01	1.0368E+07	1.0000E+00	1.1657E+00	1.1756E+00	6.0805E+03	2.9597E+03	2.5163E+03	6.6371E-01	2.6410E+06	1.0369E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
3.6002E+01	1.0371E+07	1.0000E+00	1.1676E+00	1.1769E+00	6.2059E+03	2.9597E+03	2.5164E+03	6.6371E-01	2.6437E+06	1.0373E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
3.7001E+01	1.0374E+07	1.0000E+00	1.1693E+00	1.1782E+00	6.3229E+03	2.9597E+03	2.5164E+03	6.6371E-01	2.6463E+06	1.0376E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
3.8001E+01	1.0376E+07	1.0000E+00	1.1709E+00	1.1794E+00	6.4322E+03	2.9596E+03	2.5165E+03	6.6371E-01	2.6487E+06	1.0378E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
3.9001E+01	1.0379E+07	1.0000E+00	1.1724E+00	1.1805E+00	6.5344E+03	2.9596E+03	2.5166E+03	6.6371E-01	2.6510E+06	1.0381E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
4.0001E+01	1.0381E+07	1.0000E+00	1.1738E+00	1.1815E+00	6.6303E+03	2.9596E+03	2.5167E+03	6.6371E-01	2.6531E+06	1.0384E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
4.1000E+01	1.0384E+07	1.0000E+00	1.1751E+00	1.1824E+00	6.7203E+03	2.9596E+03	2.5167E+03	6.6371E-01	2.6551E+06	1.0386E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
4.2000E+01	1.0386E+07	1.0000E+00	1.1763E+00	1.1833E+00	6.8049E+03	2.9596E+03	2.5168E+03	6.6371E-01	2.6570E+06	1.0388E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
4.3004E+01	1.0388E+07	1.0000E+00	1.1775E+00	1.1842E+00	6.8848E+03	2.9596E+03	2.5168E+03	6.6371E-01	2.6588E+06	1.0390E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
4.4004E+01	1.0390E+07	1.0000E+00	1.1786E+00	1.1849E+00	6.9599E+03	2.9595E+03	2.5169E+03	6.6371E-01	2.6605E+06	1.0392E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
4.5003E+01	1.0391E+07	1.0000E+00	1.1796E+00	1.1857E+00	7.0307E+03	2.9595E+03	2.5169E+03	6.6371E-01	2.6620E+06	1.0394E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
4.6003E+01	1.0393E+07	1.0000E+00	1.1806E+00	1.1864E+00	7.0976E+03	2.9595E+03	2.5170E+03	6.6371E-01	2.6635E+06	1.0396E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
4.7003E+01	1.0395E+07	1.0000E+00	1.1815E+00	1.1870E+00	7.1608E+03	2.9595E+03	2.5170E+03	6.6371E-01	2.6650E+06	1.0397E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
4.8003E+01	1.0396E+07	1.0000E+00	1.1823E+00	1.1877E+00	7.2208E+03	2.9595E+03	2.5170E+03	6.6371E-01	2.6663E+06	1.0399E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
4.9002E+01	1.0398E+07	1.0000E+00	1.1831E+00	1.1883E+00	7.2776E+03	2.9595E+03	2.5171E+03	6.6371E-01	2.6676E+06	1.0400E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
5.0002E+01	1.0399E+07	1.0000E+00	1.1839E+00	1.1888E+00	7.3314E+03	2.9595E+03	2.5171E+03	6.6371E-01	2.6688E+06	1.0402E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
5.1002E+01	1.0400E+07	1.0000E+00	1.1846E+00	1.1893E+00	7.3826E+03	2.9595E+03	2.5171E+03	6.6371E-01	2.6699E+06	1.0403E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
5.2002E+01	1.0401E+07	1.0000E+00	1.1853E+00	1.1898E+00	7.4313E+03	2.9595E+03	2.5172E+03	6.6371E-01	2.6710E+06	1.0404E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
5.3002E+01	1.0403E+07	1.0000E+00	1.1860E+00	1.1903E+00	7.4775E+03	2.9595E+03	2.5172E+03	6.6371E-01	2.6721E+06	1.0406E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
5.4001E+01	1.0404E+07	1.0000E+00	1.1866E+00	1.1908E+00	7.5216E+03	2.9594E+03	2.5172E+03	6.6371E-01	2.6731E+06	1.0407E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
5.4997E+01	1.0405E+07	1.0000E+00	1.1872E+00	1.1912E+00	7.5634E+03	2.9594E+03	2.5173E+03	6.6371E-01	2.6740E+06	1.0408E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
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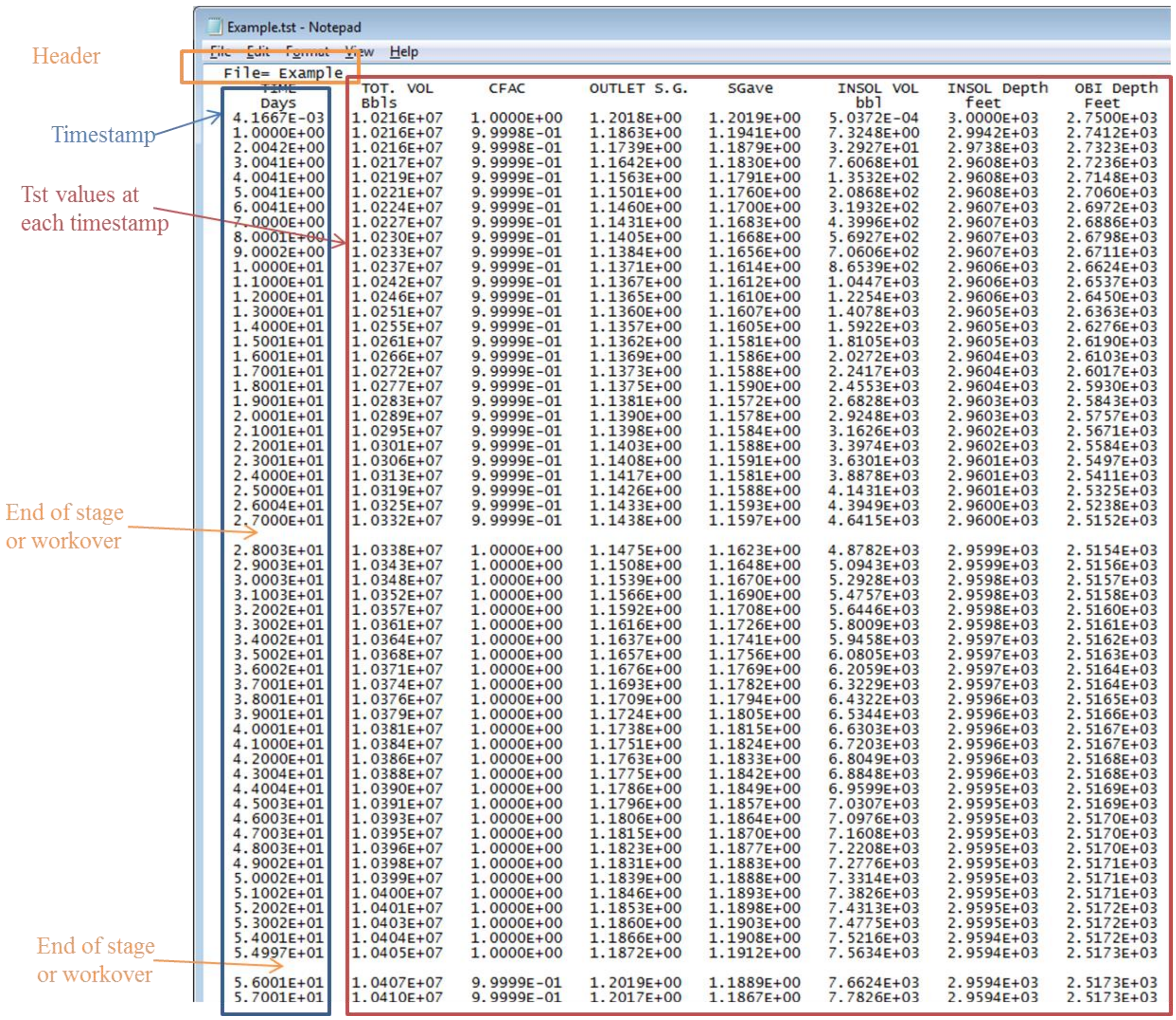
5.6001E+01	1.0407E+07	9.9999E-01	1.2019E+00	1.1889E+00	7.6624E+03	2.9594E+03	2.5173E+03	6.6371E-01	2.6764E+06	1.0410E+07	5.0208E+04	1.4002E+06	1.5063E+02	-1.3158E+06
5.7001E+01	1.0410E+07	9.9999E-01	1.2017E+00	1.1867E+00	7.7826E+03	2.9594E+03	2.5173E+03	6.6371E-01	2.6794E+06	1.0414E+07	5.0000E+04	1.4502E+06	1.5000E+02	-1.3157E+06
5.8001E+01	1.0414E+07	9.9999E-01	1.2014E+00	1.1848E+00	7.9228E+03	2.9594E+03	2.5173E+03	6.6371E-01	2.6829E+06	1.0417E+07	5.0000E+04	1.5002E+06	1.5000E+02	-1.3155E+06
5.9001E+01	1.0418E+07	9.9999E-01	1.2009E+00	1.1831E+00	8.0815E+03	2.9593E+03	2.5174E+03	6.6371E-01	2.6869E+06	1.0421E+07	5.0000E+04	1.5502E+06	1.5000E+02	-1.3154E+06
6.0001E+01	1.0422E+07	9.9999E-01	1.2002E+00	1.1816E+00	8.2569E+03	2.9593E+03	2.5174E+03	6.6371E-01	2.6913E+06	1.0426E+07	5.0000E+04	1.6002E+06	1.5000E+02	-1.3152E+06
6.1001E+01	1.0427E+07	9.9999E-01	1.1993E+00	1.1803E+00	8.4473E+03	2.9593E+03	2.5174E+03	6.6371E-01	2.6961E+06	1.0431E+07	5.0000E+04	1.6502E+06	1.5000E+02	-1.3151E+06
6.2001E+01	1.0432E+07	9.9999E-01	1.1983E+00	1.1791E+00	8.6510E+03	2.9592E+03	2.5175E+03	6.6371E-01	2.7012E+06	1.0436E+07	5.0000E+04	1.7002E+06	1.5000E+02	-1.3149E+06
6.3001E+01	1.0437E+07	9.9999E-01	1.1973E+00	1.1781E+00	8.8665E+03	2.9592E+03	2.5175E+03	6.6371E-01	2.7067E+06	1.0442E+07	5.0000E+04	1.7502E+06	1.5000E+02	-1.3148E+06
6.4001E+01	1.0443E+07	9.9999E-01	1.1962E+00	1.1771E+00	9.0923E+03	2.9592E+03	2.5175E+03	6.6371E-01	2.7124E+06	1.0448E+07	5.0000E+04	1.8002E+06	1.5000E+02	-1.3146E+06
6.5001E+01	1.0449E+07	9.9999E-01	1.1951E+00	1.1764E+00	9.3271E+03	2.9591E+03	2.5175E+03	6.6371E-01	2.7184E+06	1.0454E+07	5.0000E+04	1.8502E+06	1.5000E+02	-1.3145E+06
6.6001E+01	1.0455E+07	9.9999E-01	1.1940E+00	1.1757E+00	9.5697E+03	2.9591E+03	2.5176E+03	6.6371E-01	2.7245E+06	1.0460E+07	5.0000E+04	1.9002E+06	1.5000E+02	-1.3143E+06
6.7001E+01	1.0461E+07	9.9999E-01	1.1929E+00	1.1751E+00	9.8190E+03	2.9590E+03	2.5176E+03	6.6371E-01	2.7308E+06	1.0466E+07	5.0000E+04	1.9502E+06	1.5000E+02	-1.3142E+06
6.8001E+01	1.0467E+07	9.9999E-01	1.1920E+00	1.1746E+00	1.0074E+04	2.9590E+03	2.5176E+03	6.6371E-01	2.7373E+06	1.0473E+07	5.0000E+04	2.0002E+06	1.5000E+02	-1.3140E+06
6.8993E+01	1.0474E+07	9.9999E-01	1.1911E+00	1.1742E+00	1.0332E+04	2.9590E+03	2.5176E+03	6.6371E-01	2.7439E+06	1.0480E+07	4.9583E+04	2.0498E+06	1.4875E+02	-1.3139E+06
													--- WO 2	
7.0002E+01	1.0477E+07	1.0000E+00	1.1914E+00	1.1753E+00	1.0465E+04	2.9589E+03	2.5176E+03	6.6371E-01	2.7473E+06	1.0483E+07	0.0000E+00	2.0498E+06	0.0000E+00	-1.3139E+06

Figure 5-7. Example of a *.tst* Output File.



File= Example

TIME Days	TOT. VOL Bbls	CFAC	OUTLET S.G.	SGave	INSOL VOL bbl	INSOL Depth feet	OBI Depth Feet
4.1667E-03	1.0216E+07	1.0000E+00	1.2018E+00	1.2019E+00	5.0372E-04	3.0000E+03	2.7500E+03
1.0000E+00	1.0216E+07	9.9998E-01	1.1863E+00	1.1941E+00	7.3248E+00	2.9942E+03	2.7412E+03
2.0042E+00	1.0216E+07	9.9998E-01	1.1739E+00	1.1879E+00	3.2927E+01	2.9738E+03	2.7323E+03
3.0041E+00	1.0217E+07	9.9999E-01	1.1642E+00	1.1830E+00	7.6068E+01	2.9608E+03	2.7236E+03
4.0041E+00	1.0219E+07	9.9999E-01	1.1563E+00	1.1791E+00	1.3532E+02	2.9608E+03	2.7148E+03
5.0041E+00	1.0221E+07	9.9999E-01	1.1501E+00	1.1760E+00	2.0868E+02	2.9608E+03	2.7060E+03
6.0041E+00	1.0224E+07	9.9999E-01	1.1460E+00	1.1700E+00	3.1932E+02	2.9607E+03	2.6972E+03
7.0000E+00	1.0227E+07	9.9999E-01	1.1431E+00	1.1683E+00	4.3996E+02	2.9607E+03	2.6886E+03
8.0001E+00	1.0230E+07	9.9999E-01	1.1405E+00	1.1668E+00	5.6927E+02	2.9607E+03	2.6798E+03
9.0002E+00	1.0233E+07	9.9999E-01	1.1384E+00	1.1656E+00	7.0606E+02	2.9607E+03	2.6711E+03
1.0000E+01	1.0237E+07	9.9999E-01	1.1371E+00	1.1614E+00	8.6539E+02	2.9606E+03	2.6624E+03
1.1000E+01	1.0242E+07	9.9999E-01	1.1367E+00	1.1612E+00	1.0447E+03	2.9606E+03	2.6537E+03
1.2000E+01	1.0246E+07	9.9999E-01	1.1365E+00	1.1610E+00	1.2254E+03	2.9606E+03	2.6450E+03
1.3000E+01	1.0251E+07	9.9999E-01	1.1360E+00	1.1607E+00	1.4078E+03	2.9605E+03	2.6363E+03
1.4000E+01	1.0255E+07	9.9999E-01	1.1357E+00	1.1605E+00	1.5922E+03	2.9605E+03	2.6276E+03
1.5001E+01	1.0261E+07	9.9999E-01	1.1362E+00	1.1581E+00	1.8105E+03	2.9605E+03	2.6190E+03
1.6001E+01	1.0266E+07	9.9999E-01	1.1369E+00	1.1586E+00	2.0272E+03	2.9604E+03	2.6103E+03
1.7001E+01	1.0272E+07	9.9999E-01	1.1373E+00	1.1588E+00	2.2417E+03	2.9604E+03	2.6017E+03
1.8001E+01	1.0277E+07	9.9999E-01	1.1375E+00	1.1590E+00	2.4553E+03	2.9604E+03	2.5930E+03
1.9001E+01	1.0283E+07	9.9999E-01	1.1381E+00	1.1572E+00	2.6828E+03	2.9603E+03	2.5843E+03
2.0001E+01	1.0289E+07	9.9999E-01	1.1390E+00	1.1578E+00	2.9248E+03	2.9603E+03	2.5757E+03
2.1001E+01	1.0295E+07	9.9999E-01	1.1398E+00	1.1584E+00	3.1626E+03	2.9602E+03	2.5671E+03
2.2001E+01	1.0301E+07	9.9999E-01	1.1403E+00	1.1588E+00	3.3974E+03	2.9602E+03	2.5584E+03
2.3001E+01	1.0306E+07	9.9999E-01	1.1408E+00	1.1591E+00	3.6301E+03	2.9601E+03	2.5497E+03
2.4000E+01	1.0313E+07	9.9999E-01	1.1417E+00	1.1581E+00	3.8878E+03	2.9601E+03	2.5411E+03
2.5000E+01	1.0319E+07	9.9999E-01	1.1426E+00	1.1588E+00	4.1431E+03	2.9601E+03	2.5325E+03
2.6004E+01	1.0325E+07	9.9999E-01	1.1433E+00	1.1593E+00	4.3949E+03	2.9600E+03	2.5238E+03
2.7000E+01	1.0332E+07	9.9999E-01	1.1438E+00	1.1597E+00	4.6415E+03	2.9600E+03	2.5152E+03
2.8003E+01	1.0338E+07	1.0000E+00	1.1475E+00	1.1623E+00	4.8782E+03	2.9599E+03	2.5154E+03
2.9003E+01	1.0343E+07	1.0000E+00	1.1508E+00	1.1648E+00	5.0943E+03	2.9599E+03	2.5156E+03
3.0003E+01	1.0348E+07	1.0000E+00	1.1539E+00	1.1670E+00	5.2928E+03	2.9598E+03	2.5157E+03
3.1003E+01	1.0352E+07	1.0000E+00	1.1566E+00	1.1690E+00	5.4757E+03	2.9598E+03	2.5158E+03
3.2002E+01	1.0357E+07	1.0000E+00	1.1592E+00	1.1708E+00	5.6446E+03	2.9598E+03	2.5160E+03
3.3002E+01	1.0361E+07	1.0000E+00	1.1616E+00	1.1726E+00	5.8009E+03	2.9598E+03	2.5161E+03
3.4002E+01	1.0364E+07	1.0000E+00	1.1637E+00	1.1741E+00	5.9458E+03	2.9597E+03	2.5162E+03
3.5002E+01	1.0368E+07	1.0000E+00	1.1657E+00	1.1756E+00	6.0805E+03	2.9597E+03	2.5163E+03
3.6002E+01	1.0371E+07	1.0000E+00	1.1676E+00	1.1769E+00	6.2059E+03	2.9597E+03	2.5164E+03
3.7001E+01	1.0374E+07	1.0000E+00	1.1693E+00	1.1782E+00	6.3229E+03	2.9597E+03	2.5164E+03
3.8001E+01	1.0376E+07	1.0000E+00	1.1709E+00	1.1794E+00	6.4322E+03	2.9596E+03	2.5165E+03
3.9001E+01	1.0379E+07	1.0000E+00	1.1724E+00	1.1805E+00	6.5344E+03	2.9596E+03	2.5166E+03
4.0001E+01	1.0381E+07	1.0000E+00	1.1738E+00	1.1815E+00	6.6303E+03	2.9596E+03	2.5167E+03
4.1000E+01	1.0384E+07	1.0000E+00	1.1751E+00	1.1824E+00	6.7203E+03	2.9596E+03	2.5167E+03
4.2000E+01	1.0386E+07	1.0000E+00	1.1763E+00	1.1833E+00	6.8049E+03	2.9596E+03	2.5168E+03
4.3004E+01	1.0388E+07	1.0000E+00	1.1775E+00	1.1842E+00	6.8848E+03	2.9596E+03	2.5168E+03
4.4004E+01	1.0390E+07	1.0000E+00	1.1786E+00	1.1849E+00	6.9599E+03	2.9595E+03	2.5169E+03
4.5003E+01	1.0391E+07	1.0000E+00	1.1796E+00	1.1857E+00	7.0307E+03	2.9595E+03	2.5169E+03
4.6003E+01	1.0393E+07	1.0000E+00	1.1806E+00	1.1864E+00	7.0976E+03	2.9595E+03	2.5170E+03
4.7003E+01	1.0395E+07	1.0000E+00	1.1815E+00	1.1870E+00	7.1608E+03	2.9595E+03	2.5170E+03
4.8003E+01	1.0396E+07	1.0000E+00	1.1823E+00	1.1877E+00	7.2208E+03	2.9595E+03	2.5170E+03
4.9002E+01	1.0398E+07	1.0000E+00	1.1831E+00	1.1883E+00	7.2776E+03	2.9595E+03	2.5171E+03
5.0002E+01	1.0399E+07	1.0000E+00	1.1839E+00	1.1888E+00	7.3314E+03	2.9595E+03	2.5171E+03
5.1002E+01	1.0400E+07	1.0000E+00	1.1846E+00	1.1893E+00	7.3826E+03	2.9595E+03	2.5171E+03
5.2002E+01	1.0401E+07	1.0000E+00	1.1853E+00	1.1898E+00	7.4313E+03	2.9595E+03	2.5172E+03
5.3002E+01	1.0403E+07	1.0000E+00	1.1860E+00	1.1903E+00	7.4775E+03	2.9595E+03	2.5172E+03
5.4001E+01	1.0404E+07	1.0000E+00	1.1866E+00	1.1908E+00	7.5216E+03	2.9594E+03	2.5172E+03
5.4997E+01	1.0405E+07	1.0000E+00	1.1872E+00	1.1912E+00	7.5634E+03	2.9594E+03	2.5173E+03
5.6001E+01	1.0407E+07	9.9999E-01	1.2019E+00	1.1889E+00	7.6624E+03	2.9594E+03	2.5173E+03
5.7001E+01	1.0410E+07	9.9999E-01	1.2017E+00	1.1867E+00	7.7826E+03	2.9594E+03	2.5173E+03

Figure 5-8. Annotated *.tst* Output File – Left-Half.

Tst values at each timestamp (cont.)

End of stage or workover

End of stage or workover

INSOL.VNT Bbls	ULLAGE Bbls	ZUVOL BBL	QI BPD	QITOT BBL	QFIL BPD	QFILTOT BBL
4.0431E-07	1.1753E+06	1.0211E+07	2.0833E+02	2.0833E+02	0.0000E+00	0.0000E+00
2.1311E-03	1.2245E+06	1.0211E+07	4.9792E+04	5.0000E+04	-4.9112E+04	-4.9112E+04
8.9887E-03	1.2747E+06	1.0212E+07	5.0208E+04	1.0021E+05	-4.9494E+04	-9.8607E+04
2.0575E-02	1.3250E+06	1.0213E+07	5.0000E+04	1.5021E+05	-4.9244E+04	-1.4785E+05
3.6482E-02	1.3758E+06	1.0215E+07	5.0000E+04	2.0021E+05	-4.9195E+04	-1.9705E+05
5.6139E-02	1.4268E+06	1.0217E+07	5.0000E+04	2.5021E+05	-4.9146E+04	-2.4619E+05
7.8946E-02	1.4784E+06	1.0219E+07	5.0000E+04	3.0021E+05	-4.9011E+04	-2.9520E+05
1.0347E-01	1.5302E+06	1.0223E+07	4.9792E+04	3.5000E+05	-4.8764E+04	-3.4397E+05
1.2967E-01	1.5825E+06	1.0226E+07	5.0000E+04	4.0000E+05	-4.8933E+04	-3.9290E+05
1.5729E-01	1.6350E+06	1.0230E+07	5.0000E+04	4.5000E+05	-4.8901E+04	-4.4180E+05
1.8621E-01	1.6877E+06	1.0234E+07	5.0000E+04	5.0000E+05	-4.8808E+04	-4.9061E+05
2.1551E-01	1.7409E+06	1.0238E+07	5.0000E+04	5.5000E+05	-4.8726E+04	-5.3934E+05
2.4492E-01	1.7942E+06	1.0243E+07	5.0000E+04	6.0000E+05	-4.8720E+04	-5.8806E+05
2.7449E-01	1.8477E+06	1.0248E+07	5.0000E+04	6.5000E+05	-4.8712E+04	-6.3677E+05
3.0425E-01	1.9012E+06	1.0253E+07	5.0000E+04	7.0000E+05	-4.8703E+04	-6.8547E+05
3.3428E-01	1.9551E+06	1.0258E+07	5.0000E+04	7.5000E+05	-4.8561E+04	-7.3403E+05
3.6375E-01	2.0091E+06	1.0264E+07	5.0000E+04	8.0000E+05	-4.8569E+04	-7.8260E+05
3.9281E-01	2.0633E+06	1.0269E+07	5.0000E+04	8.5000E+05	-4.8580E+04	-8.3118E+05
4.2163E-01	2.1174E+06	1.0275E+07	5.0000E+04	9.0000E+05	-4.8585E+04	-8.7977E+05
4.5032E-01	2.1717E+06	1.0281E+07	5.0000E+04	9.5000E+05	-4.8527E+04	-9.2829E+05
4.7860E-01	2.2262E+06	1.0287E+07	5.0000E+04	1.0000E+06	-4.8467E+04	-9.7676E+05
5.0628E-01	2.2808E+06	1.0293E+07	5.0000E+04	1.0500E+06	-4.8488E+04	-1.0252E+06
5.3351E-01	2.3354E+06	1.0299E+07	5.0000E+04	1.1000E+06	-4.8502E+04	-1.0738E+06
5.6040E-01	2.3900E+06	1.0306E+07	5.0000E+04	1.1500E+06	-4.8512E+04	-1.1223E+06
5.8704E-01	2.4448E+06	1.0312E+07	5.0000E+04	1.2000E+06	-4.8409E+04	-1.1707E+06
6.1310E-01	2.4997E+06	1.0319E+07	5.0000E+04	1.2500E+06	-4.8421E+04	-1.2191E+06
6.3871E-01	2.5549E+06	1.0325E+07	5.0208E+04	1.3002E+06	-4.8645E+04	-1.2677E+06
6.6371E-01	2.6096E+06	1.0332E+07	4.9792E+04	1.3500E+06	-4.8255E+04	-1.3160E+06
					--- WO 1	
6.6371E-01	2.6147E+06	1.0338E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6194E+06	1.0344E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6237E+06	1.0349E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6277E+06	1.0354E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6314E+06	1.0358E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6348E+06	1.0362E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6380E+06	1.0366E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6410E+06	1.0369E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6437E+06	1.0373E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6463E+06	1.0376E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6487E+06	1.0378E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6510E+06	1.0381E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6531E+06	1.0384E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6551E+06	1.0386E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6570E+06	1.0388E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6588E+06	1.0390E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6605E+06	1.0392E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6620E+06	1.0394E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6635E+06	1.0396E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6650E+06	1.0397E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6663E+06	1.0399E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6676E+06	1.0400E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6688E+06	1.0402E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6699E+06	1.0403E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6710E+06	1.0404E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6721E+06	1.0406E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6731E+06	1.0407E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
6.6371E-01	2.6740E+06	1.0408E+07	0.0000E+00	1.3500E+06	0.0000E+00	-1.3160E+06
					=== END 1	
6.6371E-01	2.6764E+06	1.0410E+07	5.0208E+04	1.4002E+06	1.5063E+02	-1.3158E+06

Figure 5-9. Annotated .*tst* Output File – Right-Half.

Header – Name of the file and the column labels.

Tot. Vol – Total cavern volume at the given time.

CFAC – Measure of the "stability" (mass balance) of the code. When SANSMIC is performing as expected, its value is or is approaching 1.0. The further away from 1.0, the less reliable the results. If not close to 1, decrease time step and rerun simulation.

Outlet S.G. – Specific gravity of the produced brine.

SGave – Average specific gravity of the brine within the cavern.

Insol Vol	–	Total volume, in bbls, of insoluble created that has accumulated at the bottom of the cavern since the start of the simulation.
Insol Depth	–	Depth of the top of the insoluble level, in other words, it gives the depth to the actual bottom of the cavern.
OBI Depth	–	Depth of the OBI.
Insol Vnt	–	Volume of insolubles brought to the surface entrained in the brine, in bbls.
Ullage	–	Volume of cavern available for oil (or volume of brine) above the ullage reference depth
Zuvol	–	Volume of the cavern above the ullage reference point
Qi	–	Rate of injection of brine in bbl/day
Qitot	–	Cumulative volume of the injected brine since the beginning of the simulation
Qfil	–	Rate of the oil injection in bbl/day
QfilTot.	–	Cumulative volume of the oil injected since the beginning of the simulation
End of Stage or workover	–	Label identifying end of current stage or workover with stage count.

5.4 ***.*rad*** Output File Description

The ***.rad*** file is the cavern radius profile file. It tabulates the calculated radius for each specified output time. It begins with a small header and then gives the radius value for each grid point (vertically) at each specified time step. A screen shot of an example ***.rad*** file is shown in Figure 5-10. For greater detail, the upper-left of the example ***.rad*** file is repeated in Figure 5-11 with annotations. Annotations are detailed below the figures.

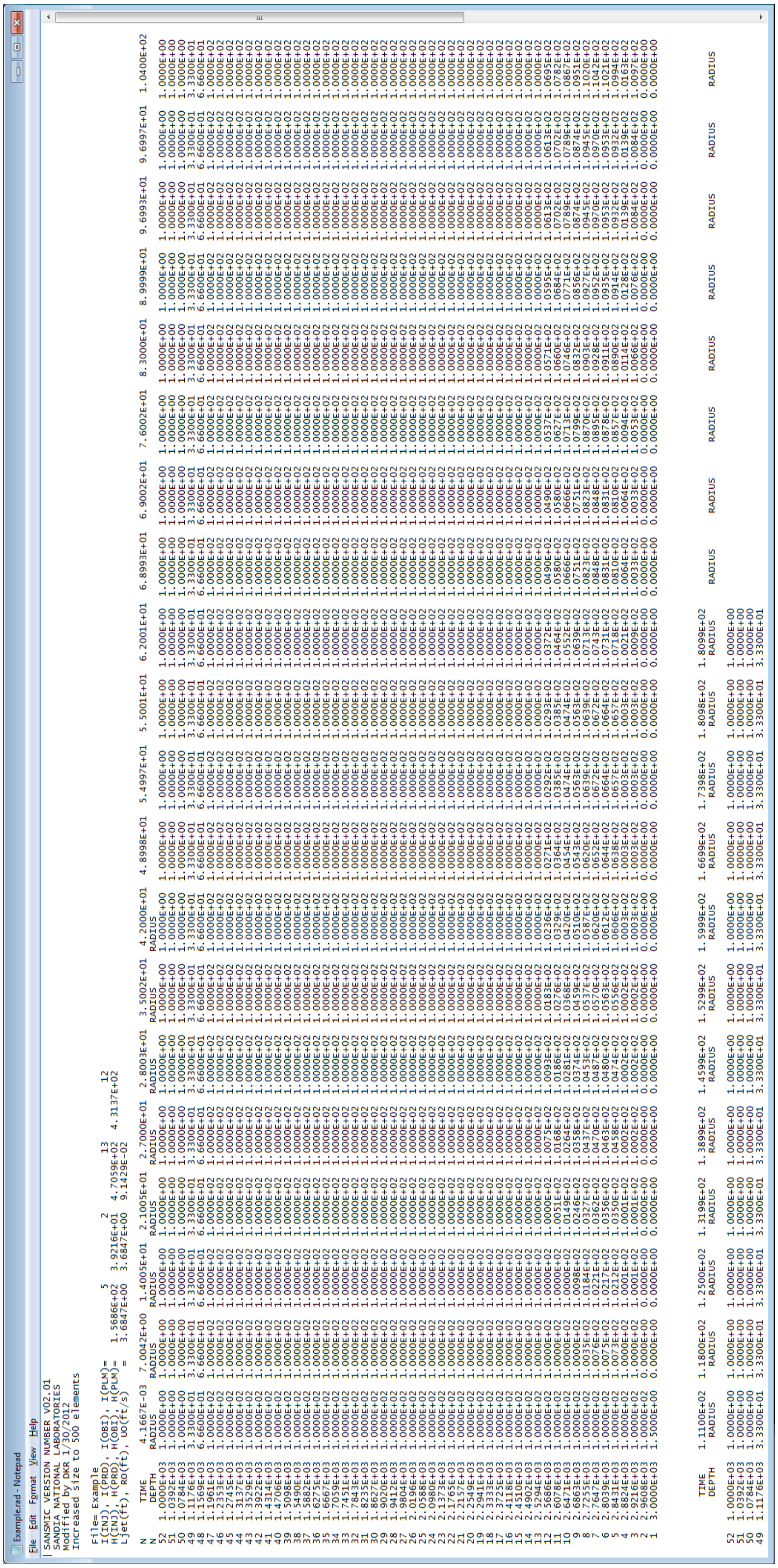


Figure 5-10. Example of the *.rad* Output file.

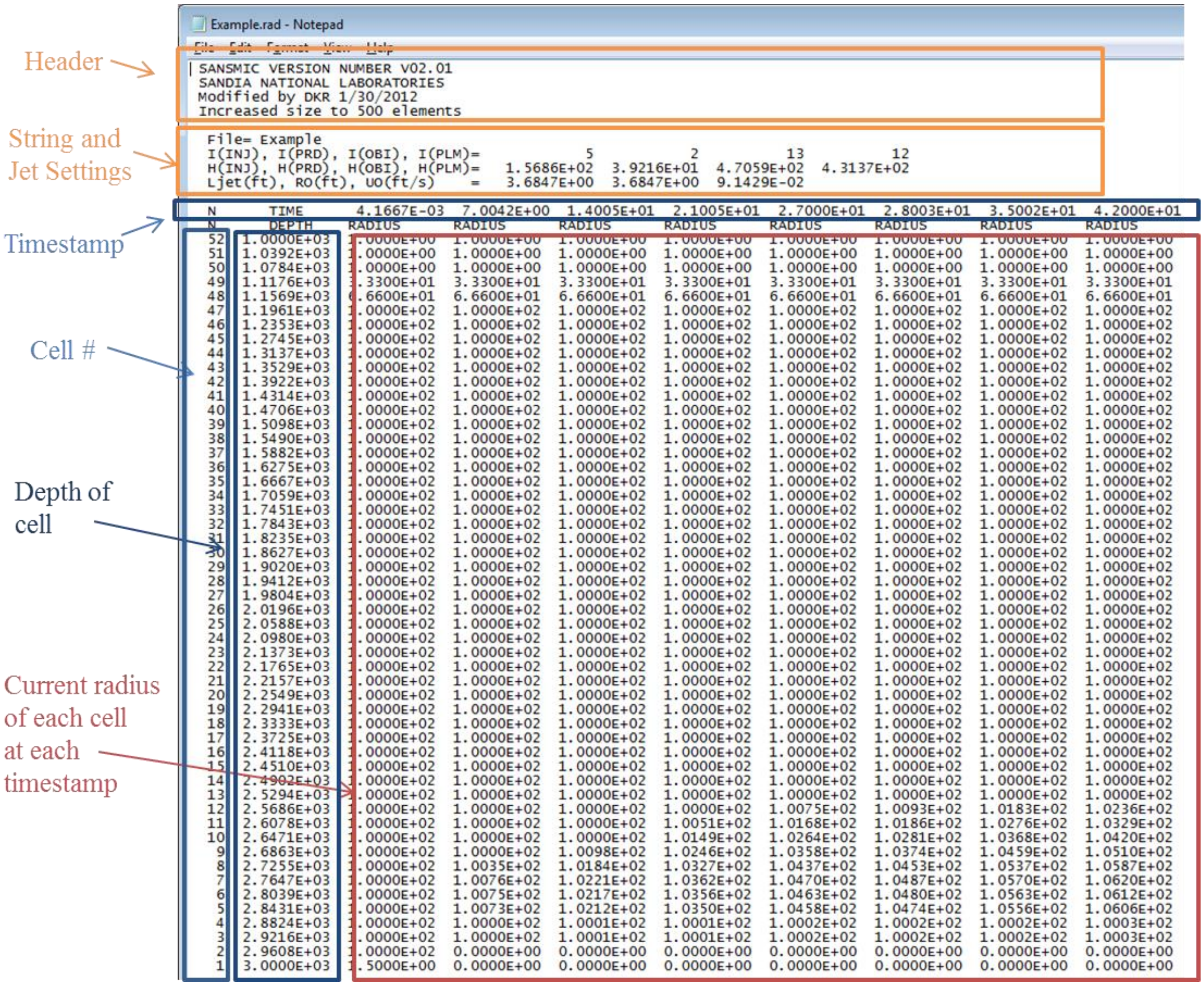


Figure 5-11. Annotated *.rad* Output File.

Header	–	Standard software identification information including: version number (v02.01), owner (Sandia National Laboratories), initials of modifier (DKR) and date (1/20/2012) of last significant modification. It should be noted that additional modifications to the source code were made in 2015, but only for code cleanup - changes to the comments and variable naming.
String and Jet Settings	–	• input file name • the cell location of the injection and production strings, the OBI, and the plume • the height above the cavern floor for the same set of variables; • the jet length, Ljet, initial radius of plume, RO, and initial velocity of the plume, UO.

Timestamp – Output simulation time in days for each column. If there are more time steps recorded than fit in this line, the timestamp and data are continued in subsequent blocks

Grid point index – Grid point (or node) index is numbered from the bottom of the cavern up but printed from top down.

Depth – Grid point depth, ft.

Radius – Radius value of each grid point, ft.

5.5 ****.dra* Output File Description**

The ***.dra*** file is the change-in-radius or "delta radius" file. It has the standard header and then gives the change in radius as a function of depth (vertically) at each specified time (horizontally). A screenshot of an example ***.dra*** file is shown in Figure 5-12.

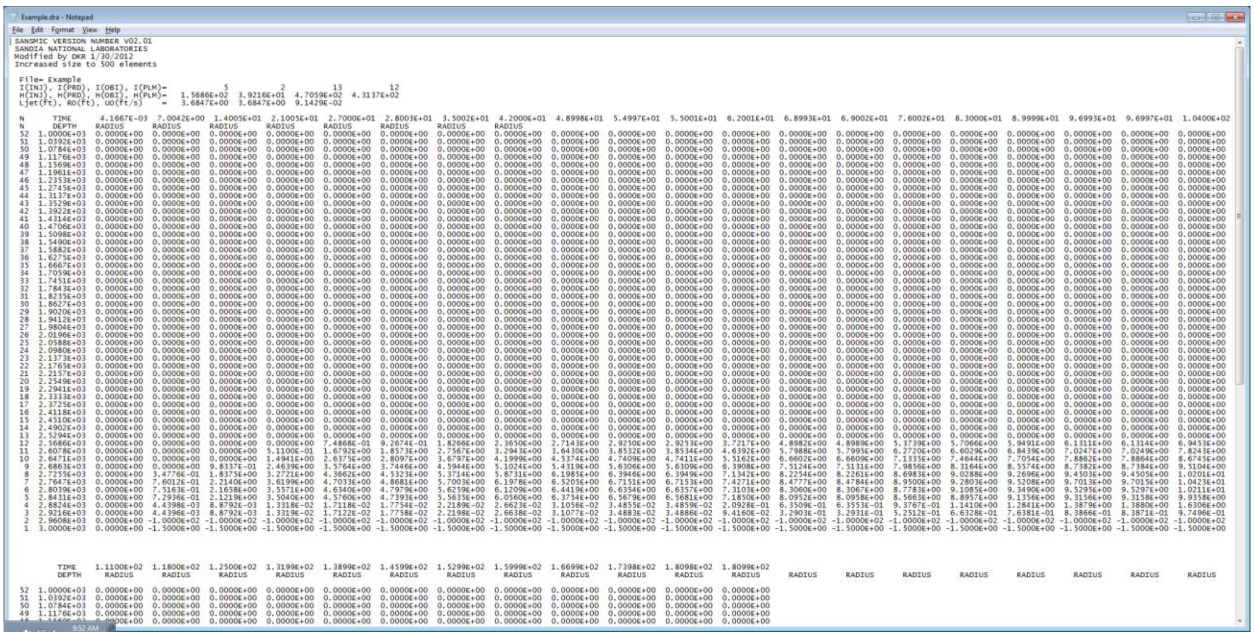
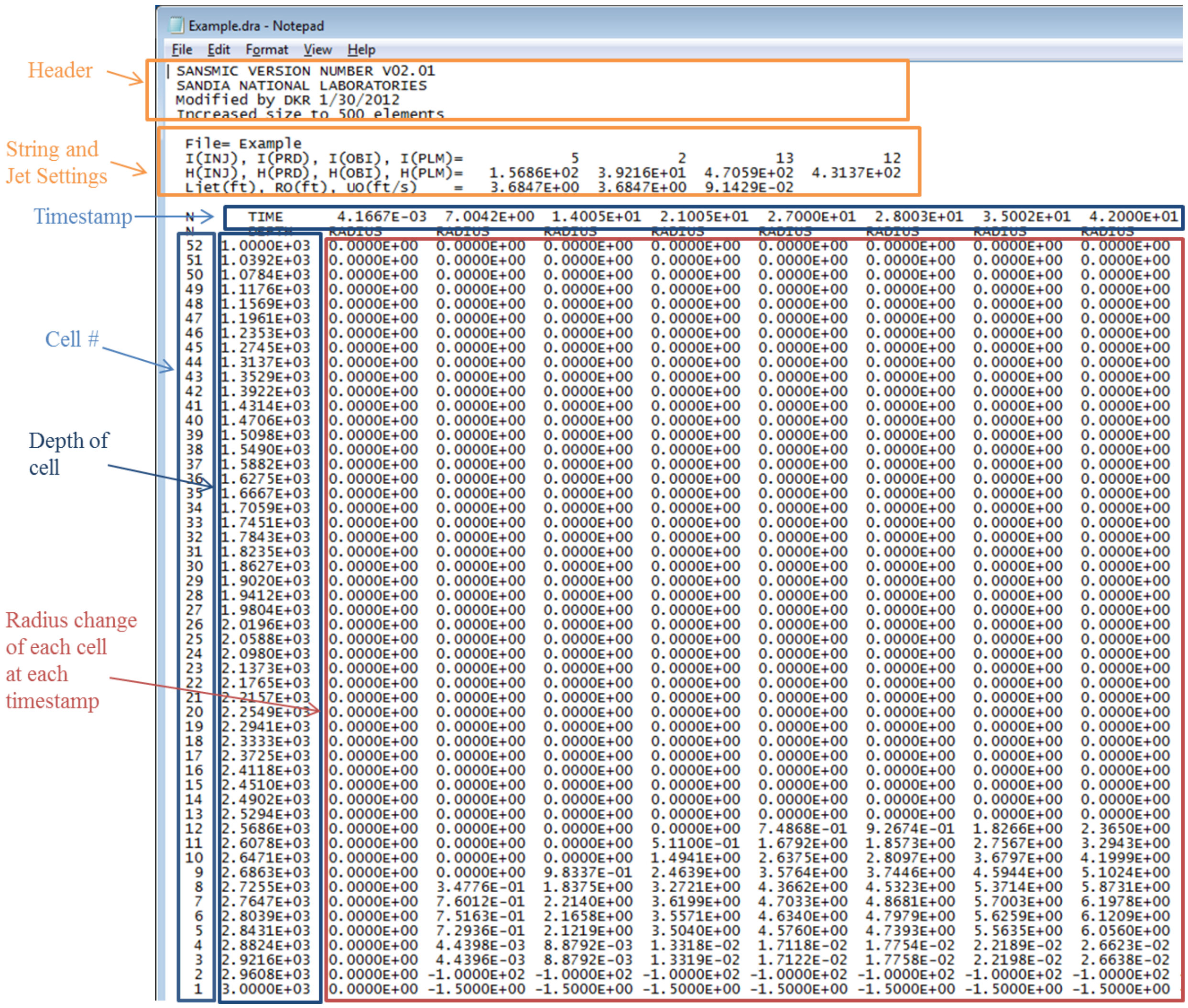


Figure 5-12. Example of *dra* Output File.

For greater detail, the same example file is repeated in Figure 5-13 with the top-left highlighted with annotations. ***.dra*** output file annotations are described in more detail below.




```
SANSMIC VERSION NUMBER V02.01
SANDIA NATIONAL LABORATORIES
Modified by DKR 1/30/2012
Increased size to 500 elements

 File= Example
 I(INJ), I(PRD), I(OBI), I(PLM)=          5          2         13         12
 H(INJ), H(PRD), H(OBI), H(PLM)= 1.5686E+02 3.9216E+01 4.7059E+02 4.3137E+02
 Ljet(ft), RO(ft), UO(ft/s)     = 3.6847E+00 3.6847E+00 9.1429E-02

  N    TIME      4.1667E-03  7.0042E+00  1.4005E+01  2.1005E+01  2.7000E+01  2.8003E+01  3.5002E+01  4.2000E+01
  N    DEPTH     RADIUS      RADIUS      RADIUS      RADIUS      RADIUS      RADIUS      RADIUS      RADIUS
 52  1.0000E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 51  1.0392E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 50  1.0784E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 49  1.1176E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 48  1.1569E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 47  1.1961E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 46  1.2353E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 45  1.2745E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 44  1.3137E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 43  1.3529E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 42  1.3922E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 41  1.4314E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 40  1.4706E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 39  1.5098E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 38  1.5490E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 37  1.5882E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 36  1.6275E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 35  1.6667E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 34  1.7059E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 33  1.7451E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 32  1.7843E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 31  1.8235E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 30  1.8627E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 29  1.9020E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 28  1.9412E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 27  1.9804E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 26  2.0196E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 25  2.0588E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 24  2.0980E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 23  2.1373E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 22  2.1765E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 21  2.2157E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 20  2.2549E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 19  2.2941E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 18  2.3333E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 17  2.3725E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 16  2.4118E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 15  2.4510E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 14  2.4902E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 13  2.5294E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 12  2.5686E+03  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00  7.4868E-01  9.2674E-01  1.8266E+00  2.3650E+00
 11  2.6078E+03  0.0000E+00  0.0000E+00  0.0000E+00  5.1100E-01  1.6792E+00  1.8573E+00  2.7567E+00  3.2943E+00
 10  2.6471E+03  0.0000E+00  0.0000E+00  0.0000E+00  1.4941E+00  2.6375E+00  2.8097E+00  3.6797E+00  4.1999E+00
  9  2.6863E+03  0.0000E+00  0.0000E+00  9.8337E-01  2.4639E+00  3.5764E+00  3.7446E+00  4.5944E+00  5.1024E+00
  8  2.7255E+03  0.0000E+00  3.4776E-01  1.8375E+00  3.2721E+00  4.3662E+00  4.5323E+00  5.3714E+00  5.8731E+00
  7  2.7647E+03  0.0000E+00  7.6012E-01  2.2140E+00  3.6199E+00  4.7033E+00  4.8681E+00  5.7003E+00  6.1978E+00
  6  2.8039E+03  0.0000E+00  7.5163E-01  2.1658E+00  3.5571E+00  4.6340E+00  4.7979E+00  5.6259E+00  6.1209E+00
  5  2.8431E+03  0.0000E+00  7.2936E-01  2.1219E+00  3.5040E+00  4.5760E+00  4.7393E+00  5.5635E+00  6.0560E+00
  4  2.8824E+03  0.0000E+00  4.4398E-03  8.8792E-03  1.3318E-02  1.7118E-02  1.7754E-02  2.2189E-02  2.6623E-02
  3  2.9216E+03  0.0000E+00  4.4396E-03  8.8792E-03  1.3319E-02  1.7122E-02  1.7758E-02  2.2198E-02  2.6638E-02
  2  2.9608E+03  0.0000E+00 -1.0000E+02 -1.0000E+02 -1.0000E+02 -1.0000E+02 -1.0000E+02 -1.0000E+02 -1.0000E+02
  1  3.0000E+03  0.0000E+00 -1.5000E+00 -1.5000E+00 -1.5000E+00 -1.5000E+00 -1.5000E+00 -1.5000E+00 -1.5000E+00
```

Figure 5-13. Annotated *.dra* Output File.

Header – Standard software identification information including: version number (v02.01), owner (Sandia National Laboratories), initials of modifier (DKR) and date (1/20/2012) of last significant modification. It should be noted that additional modifications to the source code were made in 2015, but only for code cleanup - changes to the comments and variable naming.

String and Jet Settings –

- Input file name
- Cell location of the injection and production strings, the OBI, and the plume
- Height above the cavern floor for the same set of variables
- Jet length, Ljet, initial radius of plume, RO, and initial velocity of the plume, UO.

Timestamps – Output simulation time in days for each column. If there are more time steps recorded than fit in this line, the timestamp and data are continued in subsequent blocks.

Cell Index – Grid point (or node) index is numbered from the bottom of the cavern up but printed from top down.

Depth – Grid point depth, ft.

Radius Change – The change in radius since the beginning of the simulation, ft.

5.6 *.*ddl* Output File Description

The ***.ddl*** output file is an interface file created to transfer cavern profile data for a set of consecutive full drawdown leaches from SANSMIC to the P2D (pillar-to-diameter ratio) cavern stability software. The file contains, by column: cell index, depth(ft), the initial cavern average radius (R0, ft) and the change-in-cavern radius ($r(i,t)$ – r(i,0), ft) for a series of drawdown stages (DRs→). Though originally designed for use by the P2D software, it is useful as a single portable columnar data source of leach profiles for post-processing. Note the data is listed from top of cavern down with cells and depth indexed from the bottom up.

	DEPTH	RO	DRS-->		
52	1.0000E+03	1.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
51	1.0392E+03	1.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
50	1.0784E+03	1.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
49	1.1176E+03	3.3300E+01	0.0000E+00	0.0000E+00	0.0000E+00
48	1.1569E+03	6.6600E+01	0.0000E+00	0.0000E+00	0.0000E+00
47	1.1961E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
46	1.2353E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
45	1.2745E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
44	1.3137E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
43	1.3529E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
42	1.3922E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
41	1.4314E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
40	1.4706E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
39	1.5098E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
38	1.5490E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
37	1.5882E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
36	1.6275E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
35	1.6667E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
34	1.7059E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
33	1.7451E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
32	1.7843E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
31	1.8235E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
30	1.8627E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
29	1.9020E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
28	1.9412E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
27	1.9804E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
26	2.0196E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
25	2.0588E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
24	2.0980E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
23	2.1373E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
22	2.1765E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
21	2.2157E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
20	2.2549E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
19	2.2941E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
18	2.3333E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
17	2.3725E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
16	2.4118E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
15	2.4510E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
14	2.4902E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
13	2.5294E+03	1.0000E+02	0.0000E+00	0.0000E+00	0.0000E+00
12	2.5686E+03	1.0000E+02	2.9250E+00	6.1311E+00	1.8865E+01
11	2.6078E+03	1.0000E+02	3.8532E+00	7.0247E+00	1.9452E+01
10	2.6471E+03	1.0000E+02	4.7409E+00	7.8862E+00	2.0159E+01
9	2.6863E+03	1.0000E+02	5.6306E+00	8.7382E+00	2.0788E+01
8	2.7255E+03	1.0000E+02	6.3946E+00	9.4503E+00	2.1197E+01
7	2.7647E+03	1.0000E+02	6.7151E+00	9.7013E+00	2.1049E+01
6	2.8039E+03	1.0000E+02	6.6354E+00	9.5295E+00	2.0335E+01
5	2.8431E+03	1.0000E+02	6.5679E+00	9.3156E+00	1.9245E+01
4	2.8824E+03	1.0000E+02	3.4855E-02	1.3879E+00	6.8420E+00
3	2.9216E+03	1.0000E+02	3.4883E-02	8.3866E-01	4.8319E+00
2	2.9608E+03	1.0000E+02	2.7216E-02	4.0428E-01	2.4668E+00
1	3.0000E+03	1.5000E+00	0.0000E+00	0.0000E+00	0.0000E+00

Figure 5-14. Example of *.ddl* Output File.

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6 References

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Appendix: Time Dependent Injection

A time dependent injection capability has been added to SANSMIC primarily for modeling the complicated development of SPR caverns. At this time the model is untested and does not add capability – it simplifies input for simulations with very few configuration changes but complicated time-varying brine and oil injection histories. Recall that the standard SANSMIC simulation required that both the cavern configuration and fluid injections be constant for a stage. The model is documented here for those who would like to pursue, validate and or modify the capability.

The model is turned on for the brine injection by replacing the RW injection variable (QI) with the string "QITable" which triggers the reading of the RW injection history in subroutine READQT. Similarly it is turned on for the oil fill history by also replacing the QFIL variable with "QFTable" which triggers the reading of the oil fill history also from subroutine READQT. Either one or both injections can be made time dependent.

Each call reads a table in the following format (time in days, rate in barrels per day):

QNum - number of periods

Qtim(1), Qval(1) -start time period 1, rate period 1

Qtim(2), Qval(2) -start time period 2, rate period 2

…

Qtim(Qnum), QVal(QNum) start time period QNum, rate period QNum

The arrays are actually double subscripted with the second subscript designating whether the data is for brine injection (1) or oil fill (2). The injection histories are specified in a 2nd input file named "input-file-root".tbl. For example mySAMSIC.tbl if the input file was named mySANSMIC.dat. The input table file must match the input file's request (either one or both injections). If both, brine is listed first followed by oil fill. Note that brine and oil injection are independent.

After the call to READQT, QI is set to the fist QITable value and QFIL is set to the first QFTable value. For each computational timestep QI and QFIL are set to appropriate values based on the current time with calls to subroutine GETQ.

Appendix: Sample Problem

A sample problem simulating the drawdown leach of SPR cavern WH105 is presented in this appendix. The primary parameters describing the problem are specified in Table A-1 and the corresponding SANSMIC input file is provided in Table A-2. Because of its size, the geometry data is shown separately in Table A-3. Note that the OBI starts at 200 ft above the floor, moves up 187 ft (from *.*tst* file) and is reset to 30 ft above the floor at the beginning of stage 2. Implied here is the re-injection of oil to move the OBI back down. The OBI is set to 0 for stage 3 telling SANSMIC to use the OBI from the end of stage 2 or 319.5 ft (from *.*tst* output file) as the starting height for the stage.

A summary of the results, shown in Figure A-1, consists of an overlay of the original cavern average radius profile and the profiles after each of the 3 modeled stages (from *.*rad* output file). The leached volume and leach efficiency histories for the simulation are shown in Figure A-2 (from *.*tst* output file). Leach efficiency is the *volume leached* / *volume injected*.

Table A-1. Primary Parameters Describing Sample Problem.

Stage	1	2	3
Mesh Size	200	200	200
LeachType	withdrawal	withdrawal	withdrawal
Workover Time, days	100	64	480
Zmax, ft	2000	2000	2000
Zinj, ft	24	24	24
Zprod, ft	1950	1950	1950
Zobi, ft	200	30	0
Zu, ft	1960	1960	1960
Qinj, BPD	15,000	45,602	84,060
rpi, in	4.925	4.925	4.925
rcaso, in	5.375	5.375	5.375
SGi	1.003	1.01	1.02
SGcav	1.2019	1.2019	1.2019
ΔT, hr	0.1	0.1	0.1
Bottom, ft	4550	4550	4550
Stage Duration, days	43	43	97
Stage Injected Volume, bbl	645,000	1,960,886	8,153,820
Cumulative inject volume, bbl	645,000	2,605,886	10,759,706

Table A-2. Sample Problem Input File Corresponding to Problem Parameters in Table 1.

```
$ BM3 Drawdown Leach for P2D
$ $
WH105 Step 1 - Brine inj 10/11/2005-12/26/2005
     200       1   16800       0       0    2400       1       2       0
    2000      24    1950     200    1960
   15000
   4.925   5.375   4.925   5.375
   1.003  1.2019
     0.1    1032
       0       0       0
```

(Geometry data goes here. See Table A-3.)

```
     1.0    0.04    4550    4550
$ Stage 2
WH105 - brine inj 7/16/11-8/28/11 Step 2 -------------------------------
     200       1   16800       1       0    1536       1       2       0
    2000      24    1950      30    1960
   45602
   4.925   5.375   4.925   5.375
    1.01  1.2019
     0.1    1032
       0       0       0
$ Stage 3
WH105 - brine inj 11/4/11-2/12/12 Step 3a -------------------------------
     200       1   16800       1       0   11520       1       2       0
    2000      24    1950       0    1960
   84060
   4.925   5.375   4.925   5.375
    1.02  1.2019
     0.1    2328
       0       0       0
```

Table A-3. Sample Problem Geometry Input Data.

Original data in two long columns was broken into five sections for presentation in a more compact table. First line is number of data points. Subsequent lines are depth, radius pairs.

201									
2550	8.93	3050	114.06	3550	97.42	4050	91.31	4550	85.59
2560	9.31	3060	113.27	3560	98.16	4060	90.72		
2570	9.56	3070	112.20	3570	98.53	4070	89.91		
2580	9.81	3080	111.13	3580	98.90	4080	89.10		
2590	10.07	3090	109.96	3590	99.39	4090	88.41		
2600	10.33	3100	108.79	3600	99.87	4100	87.72		
2610	10.71	3110	106.80	3610	99.93	4110	87.23		
2620	11.09	3120	104.80	3620	99.99	4120	86.74		
2630	11.72	3130	103.27	3630	100.00	4130	86.03		
2640	12.34	3140	101.74	3640	100.02	4140	85.31		
2650	46.85	3150	99.98	3650	99.95	4150	84.63		
2660	75.65	3160	98.22	3660	99.89	4160	83.95		
2670	86.90	3170	96.56	3670	101.07	4170	83.32		
2680	110.11	3180	94.89	3680	102.25	4180	82.69		
2690	110.50	3190	95.60	3690	102.84	4190	82.10		
2700	112.17	3200	96.31	3700	103.43	4200	81.52		
2710	114.10	3210	95.26	3710	103.29	4210	80.66		
2720	116.03	3220	94.21	3720	103.14	4220	79.79		
2730	116.41	3230	92.99	3730	104.10	4230	78.74		
2740	116.79	3240	91.77	3740	105.05	4240	77.70		
2750	117.98	3250	90.47	3750	105.08	4250	77.04		
2760	119.17	3260	89.17	3760	105.10	4260	76.39		
2770	118.82	3270	87.52	3770	104.72	4270	76.02		
2780	118.47	3280	85.87	3780	104.35	4280	75.65		
2790	118.05	3290	85.20	3790	103.97	4290	75.14		
2800	117.62	3300	84.53	3800	103.58	4300	74.62		
2810	116.94	3310	85.64	3810	103.10	4310	73.93		
2820	116.25	3320	86.75	3820	102.62	4320	73.25		
2830	115.97	3330	86.29	3830	102.32	4330	72.70		
2840	115.70	3340	85.83	3840	102.02	4340	72.16		
2850	115.73	3350	85.09	3850	101.60	4350	72.05		
2860	115.76	3360	84.35	3860	101.18	4360	71.95		
2870	115.38	3370	84.17	3870	100.66	4370	72.99		
2880	115.00	3380	84.00	3880	100.14	4380	74.02		
2890	115.49	3390	85.60	3890	99.62	4390	74.25		
2900	115.98	3400	87.21	3900	99.10	4400	74.47		
2910	117.55	3410	89.35	3910	98.61	4410	76.31		
2920	119.13	3420	91.49	3920	98.13	4420	78.15		
2930	119.80	3430	91.98	3930	97.59	4430	78.57		
2940	120.48	3440	92.46	3940	97.06	4440	78.99		
2950	119.94	3450	92.59	3950	96.56	4450	80.10		
2960	119.40	3460	92.72	3960	96.07	4460	81.20		
2970	118.79	3470	92.97	3970	95.53	4470	82.01		
2980	118.19	3480	93.22	3980	94.98	4480	81.89		
2990	117.04	3490	94.19	3990	94.43	4490	81.79		
3000	115.90	3500	95.15	4000	93.88	4500	82.67		
3010	115.84	3510	95.62	4010	93.29	4510	86.82		
3020	115.79	3520	96.09	4020	92.70	4520	86.47		
3030	115.32	3530	96.39	4030	92.30	4530	86.09		
3040	114.85	3540	96.69	4040	91.91	4540	85.61		

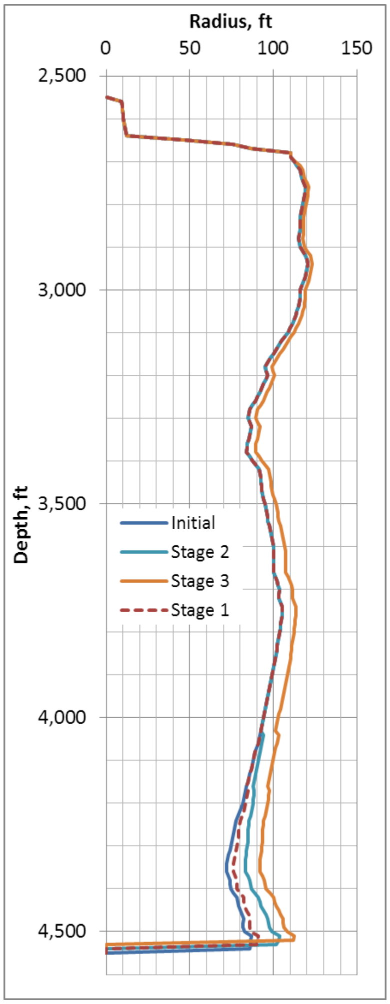

Figure A-1. Cavern Profiles.

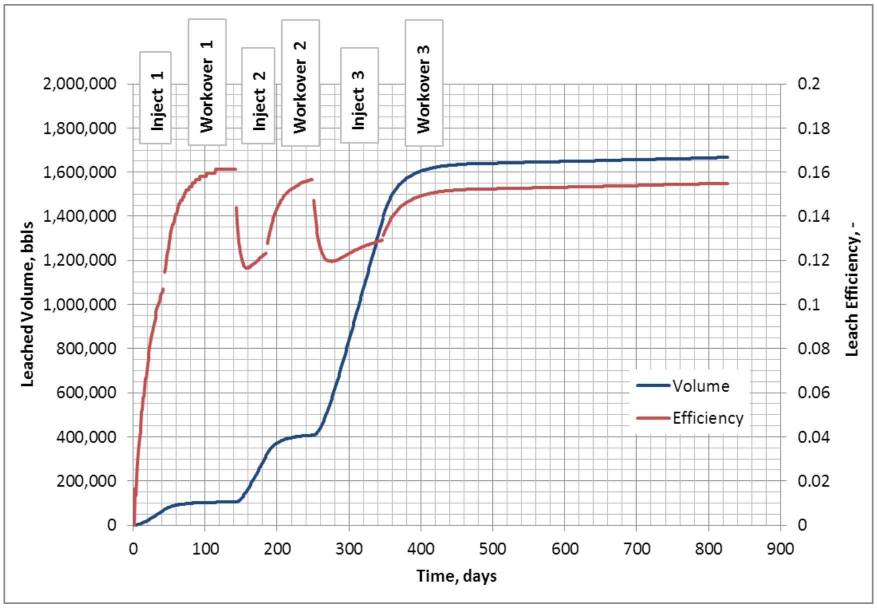

Figure A-2. Leach Volume and Efficiency Histories.

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